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Mastering the Alaskan Glacier Barriers

By Lawrence Martin,

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Glaciers have both helped and hindered exploration and settlement in Alaska, which we purchased from Russia forty-three years ago for a little less than seven and a quarter million dollars. We have since removed over seventy million dollars' worth of furs, especially the seal, one hundred and nine million dollars' worth of fish, especially salmon, and one hundred and sixty-two million dollars' worth of minerals, especially gold. In accomplishing this, men have had to cope with conditions of mountain glaciation to a greater extent than anywhere else in the world. The following paragraphs will narrate some of these difficulties and the ways they have been met.

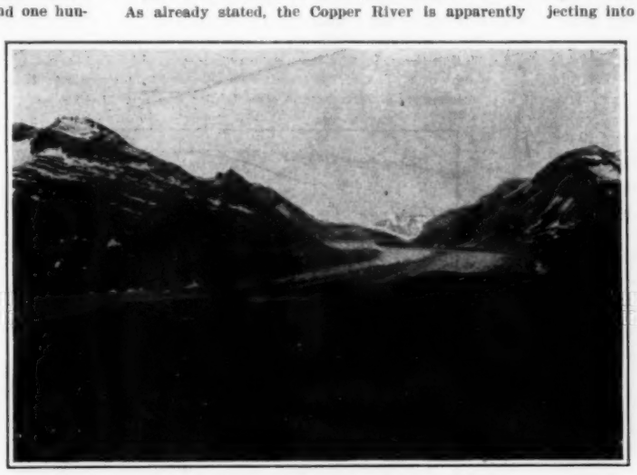
NECESSITY FOR TRAVELING OVER GLACIERS.

The Klondike district and the adjacent gold fields in Alaska were separated from the coast by a lofty mountain barrier. This could be crossed at Chilkoot and White Passes, or the lower Yukon could be ascended. The latter route was long and difficult and unexplored, the former was also hard and led through Canadian territory. Accordingly the prospectors sought a short all-American route and found that the head of ocean navigation at the east entrance of Prince William Sound, near the mouth of Copper River, was nearer the gold fields than Skagway, the beginning of the White Pass route. They did not count on the range being double, however, or on the higher passes or the glaciers. The lower Copper River valley is barred by three great glaciers projecting from either side and making river navigation impossible. Most of the prospectors, therefore, turned their attention to Port Valdez, the northeastern extremity of Prince William Sound. Here rumor said that the Russians had a route to the upper valley of the Copper River, where gold was also reported. Here, however, canyons and unexplored high passes made a pass in which there was a glacier barrier, the only highway to the interior. If the Valdez Glacier were not there this pass would furnish the shortest road or railway route to the copper mines of the Wrangell Mountains, the coal fields of the Matanuska River, and the interior of Alaska. The harbor is the best and takes ocean steamships farthest back into the land. In the valley and pass, however, is a glacier barrier.

THE GLACIER BARRIERS OF LOWER COPPER RIVER.

As already stated, the Copper River is apparently the logical highway to interior Alaska. Only a few prospectors entered this way in 1898 and 1899, however, and army officers had previously shown in 1884 and 1885 that this route was difficult, dangerous, and impracticable.

The specific difficulties and dangers occur in connection with the three great glaciers of the lower Copper River. There is now no great trunk glacier occupying the main valley, as in the case of the valley at Valdez. Instead we have three glaciers projecting into the valley of Copper River, two from the west and one from the east. These are about 30 miles from the Pacific Ocean. They were long known to the natives and to the Russians, and were seen and named by Abercrombie and Allen of the United States army in 1884 and 1885 and revisited by the former in 1898, after his trip across the Valdez Glacier highway.

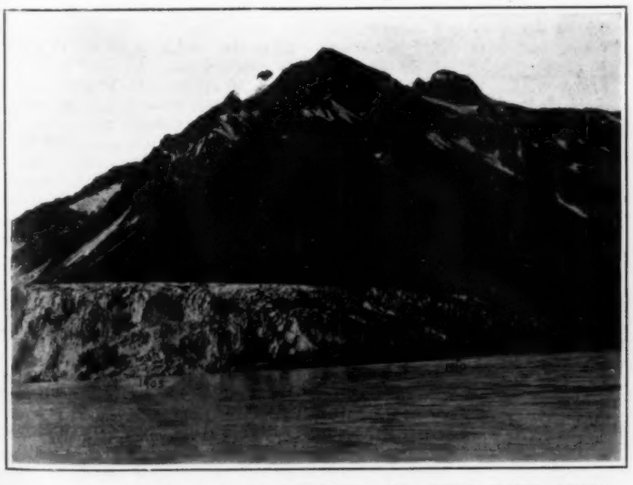


THE VALDES GLACIER, A BARRIER ON A PASS ACROSS THE CHUGACH MOUNTAINS, WHICH WAS TRAVERSED AS A HIGHWAY BY OVER FOUR THOUSAND GOLD SEEKING PROSPECTORS IN 1898

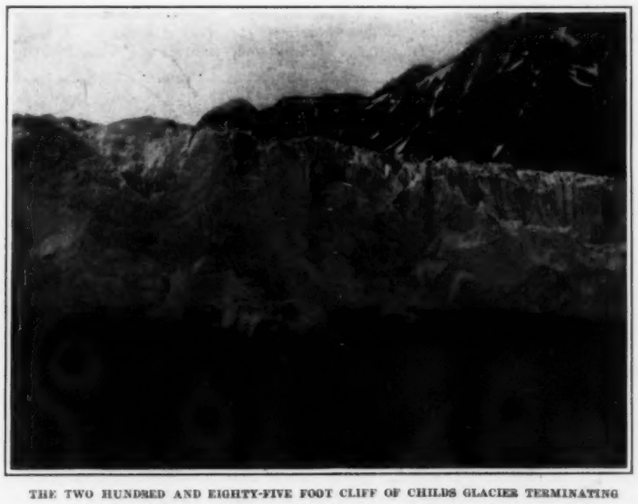
Childs Glacier, three miles wide, projects into the valley from the west, ending in a magnificent cliff, shown in one of the photographs reproduced here. It constricts the river and forms dangerous rapids, up which boats can be lined with great labor and danger because of the swift current and the great waves from falling ice masses. The river is so retarded that a lake is formed above Childs Glacier, in which Miles Glacier terminates.

Miles Glacier enters the valley from the east, as shown on the map. Part of it projects only slightly from its valley and terminates in a beautiful ice cliff 200 feet or more in height and with a frontage of two and a half miles in the lake, into which it discharges many icebergs. The remainder of the Miles Glacier terminus, which expanded into a bulb in the main valley, is a low, dark surface five or six miles wide, projecting clear across the valley from the east to the west wall and forcing the Copper River into a narrow channel called Abercrombie Rapids. At Abercrombie Rapids this dirty part of Miles Glacier has been in-

THE MILES GLACIER, SHOWING THE CLIFF, THE LAKE, AND THE RAILWAY LEADING TO THE CAR FERRY WHICH WAS IN OPERATION IN 1909, BEFORE COMPLETION OF THE BRIDGE



MOUNTAINS OF THE LOWER COPPER RIVER REGION AND CHILDS GLACIER WHICH PROJECTS INTO THE VALLEY, AND WHICH ADVANCED AS SHOWN BY THE DATES 1905 AND 1910



THE TWO HUNDRED AND EIGHTY-FIVE FOOT CLIFF OF CHILDS GLACIER TERMINATING IN COPPER RIVER. A FALL OF ICE SPLASHING SPRAY. NAVIGATION HERE IS DIFFICULT AND DANGEROUS

MASTERING THE ALASKAN GLACIER BARRIERS

active since some time during the Russian occupation of Alaska, and does not look like a glacier at all, for its ice is veneered with dirt, stones, and soil, in which a thicket of shrubs has grown. At Abercrombie Rapids the river is so narrow and swift that it plunges down in a series of boiling rapids not inferior to those below Niagara. It is unnavigable for steamers, and small boats are taken through with the utmost labor and hazard.

THE MILES GLACIER, AS SEEN FROM THE COPPER RIVER. THE MOUNTAINS IN THE BACKGROUND ARE 8,000 TO 10,000 FEET HIGH

Above Miles Glacier, where a third great glacier, the Allen, projects into the valley, this time from the west, the Copper River is forced over against the east bank. In Baird Canyon, by the glacier bulb, terminus of which has been stagnant, dirt-veneered, and tree-covered since before 1885 and probably longer.

Above Miles Glacier steamers ply on Copper River, below the river is unnavigable. The glacier barrier is of another sort from that at Valdez, but it has effectively prevented the gold-seeking prospectors and others since from utilizing the Copper River highway to the interior of Alaska.

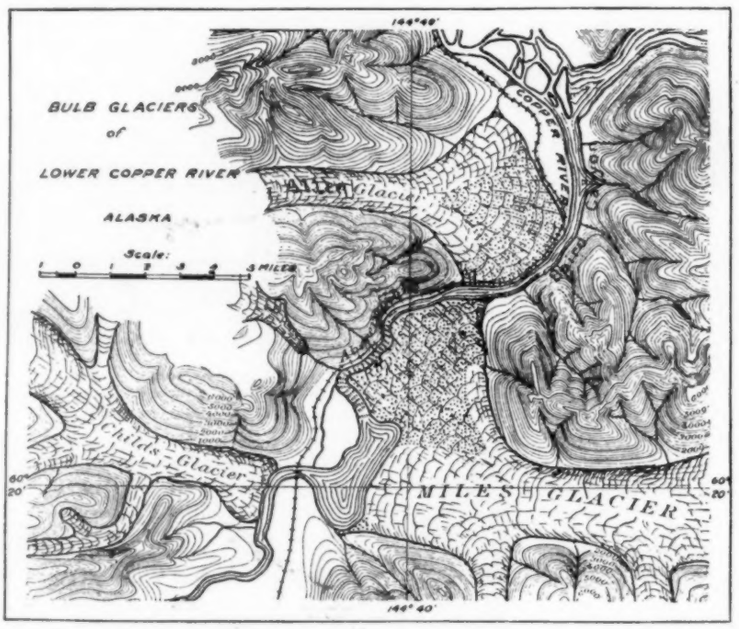
MASTERING THE GLACIER BARRIERS ON COPPER RIVER.

The need of transportation in productive Alaska, particularly of transportation for copper ore, for coal, and of cheaper and quicker access to the interior has interested large capital, and one of the first of the great trunk railways in Alaska is being built up the Copper River, and at the end of 1909 had successfully mastered the glacier barrier of the lower river, reaching the copper mines near Mt. Wrangell in the winter of 1911. It cannot start from the mouth of the river, which is too shallow for ocean steamships, but begins at Cordova at the east entrance of Prince William Sound, where one of the future metropolises of Alaska is growing rapidly in a beautiful location. The railway traverses the delta and crosses the turbid glacial stream of the Copper River near its mouth. This crossing is between Childs and Miles glaciers, where regular trains were first taken across the lake in a car ferry, which service was abandoned on the completion of the bridge in 1910. Its standard gage track winds past Abercrombie Rapids on a narrow rock shelf cut in the mountain side. It has to cross the stagnant end of the glacier above Miles Glacier, where it runs *for five miles on the ice*, because there is no other place for the roadbed. The glacier might advance, as others have done in Alaska, but the railroad could cross the river again and traverse the opposite mountain slope. Both glaciers might advance and block the way completely, but it would only be for a year or two, judging by other Alaskan glaciers.

The glaciers have been mastered, and a permanent highway across the mountains has been obtained. It took daring, skilful engineering, large capital, and, it should be said, no cent of government subsidy or land grant. We have another scenic route destined to rank with the great American wonderspots of the Grand Canyon of the Colorado, the Yellowstone Park, and Niagara Falls, for nowhere else the world over can one pass between two such glaciers and over the ice of a third in a Pullman car. The Valdez Glacier barrier was crossed temporarily, as described below. That of the lower Copper River has been mastered and made a permanent highway to the interior of Alaska, until the glaciers advance and destroy it, as several of them might do. Such an advance, however, should be short-lived, and the section of track affected could be rebuilt.

THE VALDEZ GLACIER HIGHWAY.

From the head of a beautiful fiord, Port Valdez, a gradually sloping gravel plain leads three and a quarter miles to the terminus of Valdez Glacier, 210 feet above the fiord. The glacier is 18 miles long and 1 to 2 miles wide, and rises in terraces or benches to a neight of 4,800 feet, where there is a snowy pass from which another ice tongue, the Klutena Glacier, flows northward 6 miles and ends at an elevation of 2,020 feet. From here a stream flows into Klutena Lake, which drains to the upper Copper River. In recent years the Valdez-Klutena Glacier has been inactive and little broken by crevasses, and could be used as a highway by man and horses. The end receded 630 feet from 1898 to 1909.



THE GLACIERS OF LOWER COPPER RIVER WHICH FORM A BARRIER TO NAVIGATION. THE RAILROAD RUNS BETWEEN TWO GLACIERS AND FIVE MILES OVER THE ICE OF THE THIRD GLACIER

PROSPECTORS AT THE SUMMIT OF VALDES GLACIER, 4,800 FEET ABOVE SEA LEVEL, CARRYING THEIR OUTFITS

MASTERING THE ALASKAN GLACIER BARRIERS

THE STAMPEDE TO VALDEZ.

In the late winter and early spring of 1898 the prospectors stampeded to Valdez. The gold seekers of 1897 had had a hard time crossing Chilkoot and White Passes, and this new route, which avoided these passes and the rules and regulations of the Royal Northwest Mounted Police, was eagerly followed, although in complete ignorance of what it promised. It has been estimated that over 3,000 men were landed at the head of Port Valdez in February, March, and April, 1898, and one or two thousand in the ensuing months. Beside these prospectors there was a United States government party under command of Capt. W. R. Abercrombie. It is chiefly from the accounts by Abercrombie and his lieutenants and the geologist F. C. Schrader of the United States Geological Survey that the facts stated below are gathered. There has never been in the world's history so wholesale a utilization of an ice-filled pass as a highway as that in connection with the stampede of 1898.

TRAVEL ACROSS VALDEZ GLACIER.

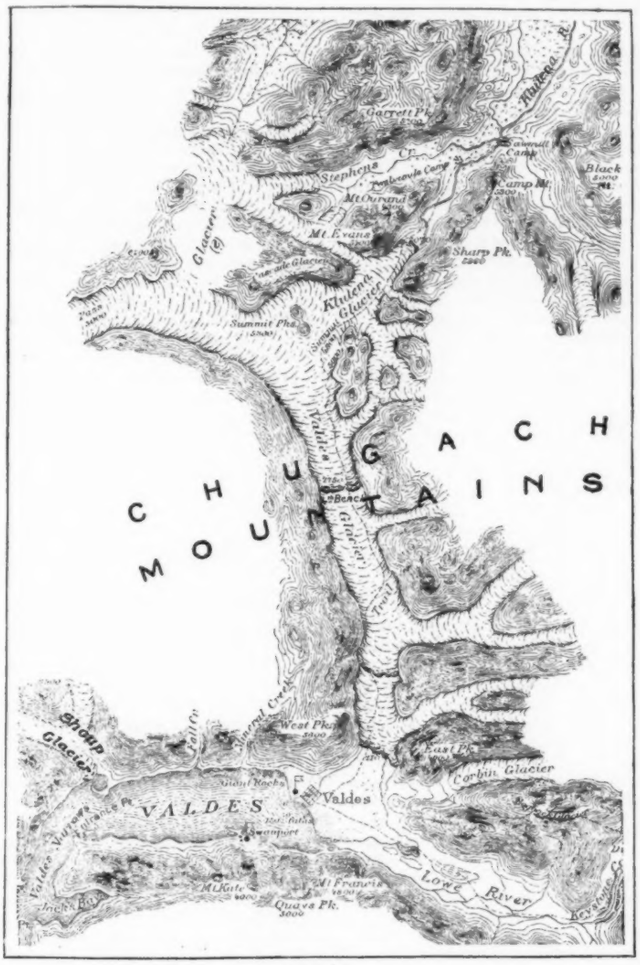
These prospectors were wholly unprepared for travel over ice. And when most of them landed at Valdez, they saw a glacier for the first time. They had sleds, but almost no other glacial equipment and suffered particularly for lack of fuel and water until experience taught them that wood must be carried, or, better, oil stoves, to make fires for cooking and melt snow or ice to get water. Few had snow shoes and none had ice axes or glacier ropes, especially necessary for rescuing those who fell into crevasses.

The trail was crooked, for, while the glacier was not severely crevassed, it was so riven by chasms that the parties had to weave back and forth between crevasses, sometimes going three or four miles to advance one mile. This was also the case when the writer traversed the lower portions of the glacier in 1904 and 1909. The way was easily lost in a fog or a snowstorm, and the many days necessary for traversing this glacier with a heavy outfit of equipment and provisions were attended by great fatigue, discomfort, and some loss of life.

Men lived for days upon the glacier, chiefly in tents. Schrader mentions one trip when he counted camps as follows: 300 people at the foot of the glacier near Valdez, 100 tents at Five Mile Cache, and 300 or 400 people at Twelve Mile Camp. The so-called benches were places of temporary settlement, for here there were steep ascents of one hundred feet or more, up some of which the loaded sleds could not be drawn. Near the summit there was a rise of 1,000 feet at an angle of nearly 15 degrees or 20 degrees. At such places provisions had to be hauled up by block and tackle or carried on men's backs. Glacier villages occupied by the succession of parties and large temporary deposits of provisions and outfit called caches were at the base and the top of this ascent. At such places of delay fuel was in especial demand, and wood brought a dollar a pound.

Sometimes it snowed continuously for 120 hours, and tents would be crushed unless shoveled off. These caches buried beneath eight to twelve feet of snow could sometimes be found again only by probing with long poles. Large snow slides came down the steep walls of the valley and out upon the glacier continually. An avalanche of this kind buried eight or ten people, all but two of whom, however, were dug out alive. Another slide buried ten horses and mules, several dogs, and a number of caches. The travelers on the glacier highway soon learned to avoid such

places of danger near the valley walls, especially for camps and caches. The accompanying map shows the trail over the glacier in 1898 and how it avoids the valley walls except when forced over to them by the crevassing near the center of the glacier. The prevalence of avalanches in the daytime, the softness of the trail, and the danger of snow blindness soon taught these men to work and travel at night, there being ample light for this purpose between 10 P. M. and morning in this northerly latitude.



THE VALDES GLACIER: SHOWING THE TRAIL BY WHICH THE PROSPECTORS TRAVELED IN 1898, AND THE TOWN OF VALDES

A FRUITLESS MASTERY OF A GLACIER BARRIER.

Despite all these difficulties the hardy prospectors mastered the glacier barrier on the coast range of Chugach Mountains. By the first of May 2,000 gold seekers had traversed the highway of ice and 1,500 more were on the way across. Many took horses, mules, and burros over successfully; two army detachments crossing with 14 and 23 pack animals respectively.

The trip down the shorter Klutena Glacier from the Valdez Glacier summit was easy and rapid, a man being able to draw as much as five or six hundred pounds in a sled. Beyond this there were rapids to be shot, there was a long lake to be crossed, and for this many of the adventurers were unprepared. But, worse of all, there was little or no gold at hand, but there was a long, hard, largely unexplored 250 miles of road over the second mountain range, the Alaska Range, to the Yukon Valley. It was upstream toiling, not downstream floating, as in the case of the route from the lakes beyond White Pass to the Eldorado.

The mastery of the glacier barrier had been fruitless. The exodus began early in the summer and prospectors streamed across the Valdez Glacier highway to take ship for home, if they had money, or to stow away or work passage, if penniless, as a great majority were. A few stayed in the Copper River valley and founded the town of Copper Center, some going out during the winter and not a few losing their lives on the glacier. Of those remaining many died during the epidemic of scurvy that scourged Copper Center and Valdez. A very few went on and found fortune the following year.

A few prospectors went across the Valdez Glacier highway early in the spring of 1899, but during the summer and since then the military trail, now a wagon road, built by the army over a lower, nonglacial pass, has been the highway of entry to the Copper River valley. A telegraph line goes this way now to Eagle and Fairbanks on the Yukon and Tanana. The glacier barrier at Valdez, mastered by thousands of poor, inadequately-equipped prospectors, who toiled prodigously and profited nothing, is still a barrier. It can be traversed, but the trail to the east is easier. Men go short distances upon its surface to prospect, one party being seen by the writer in 1904. In 1909 we found a sledge that had been abandoned by another short distance prospecting party. Though temporarily a crowded highway, the Valdez Glacier is no longer traversed, though tourists now go to its front in an automobile.

The Making of Mountains

EVEN a casual observer, as he proceeds along a country road, will sometimes notice curiously bent and twisted rocks, some of which strikingly resemble layers of crumpled cloth. The evidence that the forms of these rocks furnish of the action of some tremendous pressure in long past times, which was able to bend and fold the layers of the earth's crust, is of a kind to appeal to the eye and mind of all.

The geologist sees in the mountains themselves far greater proofs of the might of those forces of disturbance that have broken and corrugated the rocky shell of the globe.

The effectiveness of the slow contraction, which the earth has undergone as its interior has gradually cooled off, in upheaving and deforming its surface, has been beautifully illustrated by the experiments of a French geologist.

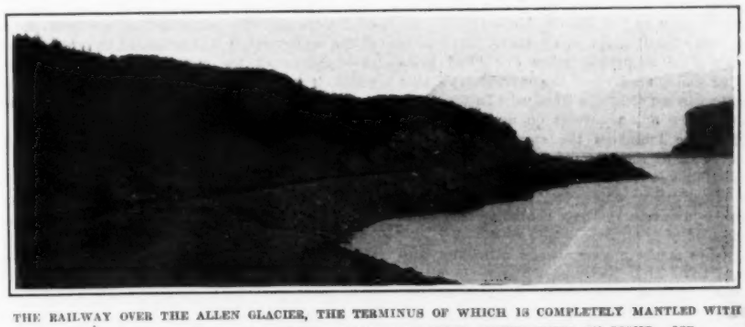
He employed a distended ball of caoutchouc made to imitate the form of the earth, slightly flattened at the poles, and covered it with a layer of beeswax. Then the ball was allowed to contract a little. Immediately the beeswax surface was thrown into folds, and fractured and upheaved in some places and depressed in others, the effect being to produce a striking resemblance to the surface of the earth, with its mountains and valleys and vast beds of broken and tilted rocks.

So, in a few minutes, by this ingenious experiment, a geological history of the earth in miniature can be enacted, and while watching it, with the aid of a little imagination, we may behold some of those mighty processes which, acting through millions of years, have gradually brought our planet into the condition in which we see it to-day.

Wireless on Aeroplane

EXPERIMENTS with wireless telegraphy from aeroplanes are being carried out in France, and one of the first to be successful was made at the Buc aeronautic grounds on board an aeroplane piloted by Maurice Farman, using wireless apparatus of the Ancel type. In the first experiments there was used a 4-inch spark coil supplied by four storage battery cells. One pole of the spark gap was connected to the steel brace wires and all the metallic mass of the aeroplane and the second pole to an aerial wire which was well insulated. This aerial was composed of two 0.04-inch copper wires hanging down parallel to each other and 150 feet long, suspended in the rear of the aeroplane. During the flight, the wires took an almost horizontal position. The total weight of the wireless outfit is 45 pounds. In the present tests M. Farman did not carry a passenger, but worked the apparatus himself. Signals were received in the aerodrome shed, using an aerial stretched along horizontally for 600 feet length and mounted on 25-foot poles. The aeroplane flew at 8 miles from the shed and the signals were always well received, using a Ferrié electrolytic detector. New experiments are being made so as to increase the range, using an 8-inch spark and a 300-foot aerial. A passenger mounted on board works the apparatus.

Grapevine Diseases.—Treating of grapevine maladies before the French Agricultural Society, M. Prilleux speaks of the great harm done by cryptogamic maladies, by the cochylis and eudemis. For these latter, salts of arsenic have been used of late, by sprinkling. It was desired to know whether the deposits left on the grapes had any bad effect on the wine, or again upon the fresh grapes. On these two points the opinion of experimenters seems to be conclusive, and practically all admit that sprinkling with arseniates or even with arseniate of lead, which is the most dangerous, has no bad effect on the wine or the grapes. M. Gervais confirms these statements, and found that no harmful ingredients could be detected in the wine. Upon the grapes it was impossible to find any but the merest traces of arseniates. The society is soon to report upon the use of arsenic salts and also nicotine.



THE RAILWAY OVER THE ALLEN GLACIER, THE TERMINUS OF WHICH IS COMPLETELY MANTLED WITH DEBRIS AND COVERED WITH SHRUBS. GLACIER ON LEFT; COPPER RIVER ON RIGHT. ICE WAS BLASTED OUT IN LAYING THE ROADBED, AND COULD BE SEEN IN THE CUTS IN 1909 AND 1910

MASTERING THE ALASKAN GLACIER BARRIERS

Fire and Burglar-Proof Safes—II*

Recent Advances in their Construction

By E. E. Watson

Concluded from Supplement No. 1845, page 295

THE fire-proof safe which will protect its contents from destruction and bring them safely through such fires as that following the San Francisco earthquake, the Baltimore fire and the Parker Building fire, is of very modern origin.

No historical evidence exists of the use of safes for protection against fire earlier than about the year 1820, at which time a portable fire-proof safe was constructed in France. This safe consisted of an outer and an inner metal box with a space between filled with some form of non-conductor. No information is obtainable regarding the details of construction or the materials used. Previous to this the only form of fire protection afforded consisted in vaults built of masonry, which, owing to their cost, were limited in use.

In the year 1826 a fire-proof safe was invented by J. Delano. This safe was made of oaken planks 3 or 4 inches in thickness, which were saturated with salt brine to render them to some degree fire-proof, and were covered on the outside with bands of iron held in place by wrought iron nails. This safe afforded only a moderate amount of fire protection. Many of them were destroyed in the great fire in New York in 1845. A safe of this type is now in the possession of the Herring-Hall-Marvin Safe Company at its Hamilton factory.

Some time between the years 1829 and 1832 James Connor of New York City constructed an iron box with a filling between the walls composed of plaster of Paris. He used this safe in his own office, but made no attempt to patent or manufacture it. In 1834 William Marr, of England, patented a safe, the peculiar feature of which consisted of sheets of mica pasted on paper, the space between the mica sheets being filled with burnt clay and powdered charcoal mixed.

In 1838, Chubb, of London, produced a safe in which a series of iron plates were used with intermediate spaces packed with wood ashes.

Coincident with these, various other freak safes were patented and placed upon the market, but none of them seem to have left any impress of their individuality on the development of the safe industry.

The first real safe patented, manufactured and put upon the market as a commodity, was introduced by Daniel Fitzgerald, of New York city, in 1834. In this safe the fire-proof composition consisted of plaster of Paris, which was first baked and then reduced to a powder, after which it was mixed with water and mica to the consistency of paste and was poured between the outer and inner walls. This filling was a good fire resistant, but its chemical action upon the iron plates composing the walls of the safe was such that it weakened the construction and rendered the safe entirely worthless in a short space of time.

Mr. Fitzgerald early associated himself with Azor Marvin, who founded the Marvin Safe Company and was long considered one of the heads of the safe industry. This Fitzgerald safe was known as the "Salamander" safe, to distinguish it from the wood-lined chest built by Delano.

In 1843 Tann Brothers invented and patented a safe which depended for its fire-proofness upon a filling consisting of ground alum mixed with powdered gypsum. These elements were thoroughly mixed and melted together, after which the mixture was pulverized and converted into a coarse powder and used in this form for the filling of the safe. The mixture when subjected to extreme heat would give off water. This safe was known as the Marvin Alum and Plaster Patent, and was exploited for many years.

During this time numerous other dry filled safes were invented and placed upon the market. Various kinds of heat-resisting elements were used in the filler, but the safes were not a success on account of the fact that in some instances the steel walls of the safe were corroded by the filler, and in other instances the heat-resisting qualities of the material used was low and many of these safes—in fact, the majority of them—failed to preserve their contents when subjected to the test of great fires.

The industry was not placed upon a solid and substantial basis until after the modern concrete filling came into use. In 1865, when Joseph L. Hall, of Cincinnati, Ohio, the (at that time) president of the Hall's Safe & Lock Company, patented what was known as Hall's Matchless Concrete Filler, a safe was made that would withstand severe fire tests and would actually improve with age. This filler was composed of cements mixed with certain liquids and contained a large proportion of steam-producing elements in solid form. In addition to its non-combustible and non-conductive qualities, it has the other important advantage of materially strengthening the entire structure. It also improves with age instead of disintegrating in the manner of all other fillers that had previously been used.

The claim is made that when heat is applied to a mixture such as this, the liquid element that is contained within it, not in a liquid form, however, but in what has been characterized as water of crystallization, is upon the application of this heat converted into steam, thereby changing the heat into work and rendering it latent.

The most successful dry fillings previously used depended for their heat-resisting qualities upon this same principle, but were a failure on account of their destructive action on the steel walls of the safes, and for the further reason that they did not add any strength to the structure.

In the event of a fire a safe is apt to be subjected to a fall, sometimes from the upper floor of a building to the basement. Its construction must be such that it will withstand this fall without exposing its interior to the destructive action of the flames. In the case of a dry-filled safe the exterior shell of metal is apt to be punctured and the dry filling sift out, leaving some part of the safe entirely unprotected.

The concrete filling above mentioned strengthens the entire safe, and by the test of great fires has proven that this added strength is one of the greatest points in its favor. The concrete filling invented by Joseph L. Hall has been improved upon, and is now used exclusively by the Herring-Hall-Marvin Safe Company in the filling of its entire line of fire-proof safes.

During the development of the industry much thought was expended upon the construction of the framework and jambs of the safe itself. A good grade of cast-iron is used in the jambs of the door and the body of the safe. This is used for the reason that cast-iron will withstand greater heat without warping than bars or plates of steel or iron. The framework of the outer box is made of angles securely welded at the corners. These angles add strength to the jamb casting and prevent its breakage in case of a fall. The outer door-plate performs the same function for the casting which serves as the jambs of the door. Particular attention is directed to this combination of metals.

The cast-iron, which will not warp under great heat, but which is apt to break as the result of a fall.

The steel angle-frames and the door-plate, which add the necessary strength to the castings so that they will be able to withstand the shock of a fall.

The fire-proof safe made fifty years ago, and filled with the concrete filling, was a creditable article, considering the advances made in related industries. It was not fitted, however, with an angle-hoop, and the outer body of the safe was necessarily much weaker than in the safes made to-day. The fit of the doors was less accurate, and the workmanship in general, as might be expected, not approaching to any degree that of to-day.

The safe had many defects. The castings mentioned above were cut away on the hinge side of the door for the lodgment of the hinges. The hinges were made with an interlocking lug or boss that closed in back of the frame. The construction was bad on account of the added metal which tended to conduct heat into the interior of the safe, and the weakening effect which it had on the frame on account of the metal that had to be cut out in order to provide space for the hinge.

The recent advances in the construction of fire-proof safes consist:

First, in the Matter of Patterns for Door and Frame Castings.—These patterns have been revised and reconstructed at large expense with a view to securing a better fit between the door and its frame. Foundry practice has improved to such an extent that castings can now be secured with much less variation in size than formerly. To keep pace with, and to take advantage of, this advance in the art of making castings, it was necessary to reconstruct the patterns. When this was done seven years ago, the tenon and groove and the interlocking-jamb features were incorporated in all of them that had not previously been so constructed. We are now using molding machines in the making of many of our door and frame castings, which has enabled us to further reduce the limit of variation in the size of the castings themselves and to fit together a door and frame with the smallest possible allowance for variation in size of castings.

Gray iron castings can now be made that will withstand a high degree of heat without warping. In the production of our castings we use those materials which have been determined by experiment to be the best adapted to the production of a casting of uniform size, strength and rigidity.

The effect of the close-fitting door, together with the features of the tenon and groove and interlocking flange, upon the relative fire-proofness of the safe is great. A closely-fitted door braces and reinforces the strength of the frame, while a loose-fitting door adds the weight of its overhang to the frame and weakens it in direct proportion to the looseness of the fit.

Second, the Framework.—The old style band hoop or frame has been superseded by the solid welded angle-frame. The front frame supports the jamb casting and provides a fastening for the hinges. This angle is a vast improvement over the old style band or bar frame.

The manner of welding the corners is of the greatest importance. We have found by experiment that the best and strongest results can be obtained only by the hand method of welding. After the angles have been mitered at the corners the edges to be joined are hammered out hot by hand, so that they will overlap each other when bent. The actual welding operation is then performed by hand and the strength of a corner so produced has been found by test to equal in nearly all cases the strength of a solid section of the angle itself—a result which we have found impossible to arrive at by any other method.

The outer section of the safe has been strengthened by reinforcing wherever experience has shown such reinforcement to be necessary. At the same time no unnecessary weight has been added. In fact, any weight that does not add proportionately to the strength of the whole structure is a serious detriment in case of a fall. In the modern safe we provide angles and bars between the front and rear frames. The angles are placed at the corners and the bars midway between. These are securely tied to the frames of the safe and provide additional means for fastening and supporting the outer steel wall. This outer steel wall, as well as the inner steel wall, is made heavy enough to properly support and retain the fire-proof composition, and light enough so as not to add any superfluous weight to the safe.

The proper proportioning of the parts relative to each other, and to their various functions, is a matter that has been given the most careful consideration in the development of the modern fire-proof safe.

The doors are hung on malleable iron ball-bearing hinges. These hinges are fastened on the outside. The introduction of the interlocking flange in the rear of the door has made it no longer necessary to mortise them into the door and jambs. The burglar would gain nothing by knocking them off. The ball bearings by their resistance to wear maintain the door in its proper relation to the frame, and provide the additional feature of ease of operation. The outside hinge as now used makes it unnecessary to cut away part of the strength of the frame as was formerly done while the inside hinge was used.

The operation of the bolting mechanism has been simplified by being made more direct. The locks now used on the outer doors are of the combination type. They are protected by steel plates to prevent drilling and the arbors or spindles are shouldered to prevent driving in or pulling out.

An additional device is also provided that will automatically hold the bolts in the locked position in case the lock is in any manner rendered inoperative.

Those features in their best form are all of comparatively recent origin, and have added much to the value of the protection afforded by the modern safe.

The inner steel doors of fire-proof safes have heretofore been guarded by ordinary key locks. The same is true of the small cash boxes usually found as a part of the cabinet equipment. In the very near future the Herring-Hall-Marvin Safe Company will equip all of its inner doors and cash boxes with changeable key locks, thereby adding greatly to their security by the facility with which keys may be changed by the user.

* *Journal* of the Franklin Institute.

A complete line of steel interiors fitted with the most improved modern filing devices will shortly be completed and placed upon the market by this same company. This will be a great advance over the type of interiors now in general use.

To the above-mentioned improvements have been added numerous other minor refinements that result from better mechanical methods, modern factory organization, and thorough inspection.

There has lately been placed upon the market by the Herring-Hall-Marvin Safe Company a modern safe fitted with a built-in system of electrical protection. This safe may be connected to a central station system or may be fitted with a local alarm. In appearance it resembles closely the ordinary fire-proof safe and is a marked improvement over the types of electrically protected safes now in use, which depend for their security upon a separate electrical cabinet encasing the safe.

In this new safe the electrical circuits are built into the safe itself. The circuits are so arranged that any attempt to wrongfully gain entrance to the safe by the manipulation of the locks, by drilling, or by any other method, will cause an alarm to ring.

The circuit connecting the safe with the alarm is a closed one and is so arranged that it cannot be tampered with without causing an alarm to ring. The Herring-Hall-Marvin Safe Company owns and controls the patents covering this type of construction.

The so-called burglar-proof safe or vault has been improved and perfected in many ways in the last ten years.

The development of the burglar-proof safe depended in a large measure upon the development of the steel industry, and to a great extent also upon the development of locks. Until such time as really burglar-proof locks had been perfected no great advance could be made in the development of the burglar-proof safe or vault.

The burglar-proof safe of to-day must be drill-proof, it must be fitted with a door that seats so closely into the opening provided for it that no liquid explosives of any kind can be forced between the door and the jamb.

Its bolting mechanism must be of sufficient strength to retain the door in its seat and it must be controlled by locks, the operation of which will leave no opening through the door for the introduction of explosives.

The modern method of arriving at these conditions differs greatly from the attempts that were made years ago. Drill-proof steel, as formerly used, consisted either of Franklinite, which was cast or poured between two solid metal walls and allowed to harden in place, or strips of so-called spring steel laid between two retaining plates of soft steel.

The drill-proof steel used in the construction of the modern burglar-proof safe or vault is what is known as five-ply steel. It consists of alternate layers of hard and soft steel rolled and welded together, the result being a plate that will, when tempered, successfully withstand the hardest drill and will yet retain enough tensile strength to resist the crushing and rending effect of modern explosives. This steel was not available in the older types of construction. It is now in general use.

The most recent improvement in burglar-proof construction is the round-door safe, and the round-door bank vault. The increased closeness of fit can be made in a round door between the door and jamb, and the possibility of actually grinding the door to its seat, makes this type of construction the highest in existence to-day.

The amount of protection afforded by the lighter forms of construction that were in use fifteen or twenty years ago, is in the light of present-day developments very inadequate. It is only in recent years that the jambs, or the union between the door and the frame, have been polished. Earlier than this the machining was roughly done, and if too much opening was left a free use of putty and paint at least made an appearance of a fit.

All this has been changed, and for the past eight or ten years no burglar-proof door has been made by a reputable builder that does not show the polished metal on the edge of the door and jambs.

There are two general types of construction in use to-day, one being characterized as laminated construction, consisting usually of alternate layers of open-hearth steel and five-ply steel, and the other being what is known as insulated constructions. This latter contains an outer section of cast steel containing in its construction insulating materials in which are imbedded drill-proof rods or bars, and an inner section of laminated construction.

The intention in this latter construction is to eliminate the danger of burning by the electric arc, by Thermite, or the oxy-acetylene flame.

There has been much discussion as to the possible use of these agents by the burglar. It is a fact, however, that long before they were considered in this connection the modern builder of bank vaults had made many experiments and had devised ways and means of overcoming practically all the danger from these sources. Many of the older types of bank vaults, however, are not as well protected in this way as are the recent ones.

The general tendency was, up until recent years, to built vaults very light in construction. An 8-inch door was considered a very heavy one. Now doors are built as thick as 28 inches, and one is now in course of construction in the factory of the Herring-Hall-Marvin Safe Company that will be, when completed, 38 inches thick from the outer face of the door to the inner face of the bolt frame plate. The total thickness over all from the surface of the operating mechanism of the door to the extreme inner surface of the glass door covering the bolt work will be 61 inches.

The greatest advances, however, in recent years, in burglar-proof construction, have been the result of the application of up-to-date mechanical methods in their production.

Modern drill-proof steel gives absolutely adequate protection against the use of the drill. Steels formerly used and incorporated in the construction of bank vaults were not, however, drill-proof to the extent that this quality exists in the present-day steels. These older types of vaults therefore are not as thoroughly burglar-proof in this sense as are the more modern ones.

When the vault manufacturer succeeded in producing a bank vault that would successfully withstand the use of a drill, he found that his vaults were subjected to attack by the use of the wedge in the crack of the door itself. The closeness of the fit of the door did not in any way interfere with the successful use of the wedge.

A system of interlocking jambs was devised which in a measure would prevent the springing of the frame away from the door, and this reinforced by the more recent overlapping flange, of these modern doors, has eliminated entirely this source of danger. No owner of a modern bank vault need fear either the drill or the wedge.

The same security exists in reference to lock spindles that are used at the present time. Formerly these were carelessly fitted and openings could be found around them for the introduction of liquid explosives. Now they are so carefully ground into the doors that it is impossible even with pressure to force around them any known liquid explosive.

The same close fit is now also made of the door in its seat. Every modern bank vault entrance is subjected to what is known as the water test, and the door must fit so closely into the jambs that it will resist the passage of water between the door and frame.

The operating mechanism of the bolt work has been greatly improved. Formerly the bolts were operated through a system of levers and bell cranks that were indirect in their action, and were frequently the source of great inconvenience to the user. The modern boltwork is operated through gears and racks, and is so balanced in its action that very little effort is required in locking and unlocking.

The hinges are better adapted to the service expected of them. In all modern vaults the doors swing on hinges fitted with ball and roller bearings of the very best design, workmanship and materials, making a door of many tons weight so easy to operate that a child can swing it in and out, yet so perfectly balanced that it will stand at any point. These bearings are fitted with means of adjustment to compensate for wear.

The pressure mechanism for seating the door into the jambs has been improved in design and construction.

The inner surfaces of the front jambs on all of the best examples of the modern doors are brought to a uniform plane to provide a perfect seat for the locking bolt wedges. These wedges have an inclined inner face parallel to the beveled bearing face of the bolts themselves. These bearing faces are made as broad and large as possible, and the wedges are separately adjusted and fitted under the bolts so that when the door is seated and the locking bolts thrown the holding and retaining power is uniformly distributed throughout the entire system.

The modern means employed for binding the locking bolt mechanism to the body of the door consists in tapering or conical bolts running well into the body of the door, each bolt separately fit to its seat, and all binding the bars through which the locking bolts operate firmly and securely to the door. This method of fastening and fitting makes the door with its bolting mechanism an indivisible unit; the holding and retaining power equaling the great strength of the solid section of the door itself.

In the older types of construction revolving bolts were used. The fit of the doors was so imperfect that it was feared that the burglar might pass a saw through the crack of the door and saw off the locking bolts.

The structure guarded by the door, or entrance, which in common practice is called the lining, has been strengthened and improved upon in many ways. The modern lining is built up of alternate layers of steel plates. A combination is made of plates of unusual toughness and high tensile strength, with drill-proof plates of five-ply welded iron and steel, all bound together and protected at the outer and inner corners by massive steel angles. The plates of adjoining layers are laid at right angles to each other and the size of the various plates are calculated so as to break the joints. The surfaces of all plates are rolled to perfect planes and the edges of plates and angles are ground to a liquid-proof fit. The angles at the corners are welded into three-way members that effectually bind the vertical and the top and bottom faces of the lining together.

The steel plates used in the construction of the modern vault will resist the penetration of the best drills. The high tensile plates will successfully resist all explosives, and the ground joints prevent the introduction of liquids.

Steels of the quality in use to-day were not obtainable in the earlier years of the industry. Machinery and machining methods were crude, and factory organization as it exists to-day, with its team work and all of its multitudinous aids to rapid and perfect production, was undreamed of.

All the foregoing that relates to improvements in bank vaults applies with equal force to burglar-proof safes. The same high-grade materials are used, and the same careful methods applied in the construction of even the smallest burglar-proof chest.

Burglar-proof safes are now made both of the laminated and also of the later solid manganese steel variety that are absolutely impervious to any known method of attack.

Coincident with the modern development of the safe and bank vault industry was that of the profession of the bank vault engineer. The industry owes much of its progress to the work done by the pioneers of this profession, William H. Hollar, John M. Mossman, George L. Daman, E. A. Strauss, Frederick W. Holmes, Benjamin F. Tripp and George L. Remington.

The days when might was right have given place to the later days when right is mighty. The safe industry stands ready to protect your valuables not only against fire and the burglar, but against organized mob violence as well.

The Cultivation of Cotton in Egypt

DURING the last few years there has been carried out important hydraulic work in Egypt, in order to provide a remedy for the great dryness of the climate and to give a greater fertility to the soil by irrigation. In this way the level of the Nile is now raised considerably and irrigation canals could be run at greater heights than before. However, this influenced the height of the underground water, and in Lower Egypt this now comes very near the surface of the ground. At the same time there was observed a lessening in the yield of cotton. In the Delta this is especially remarked, and the crop for 1909 was almost a failure. Accordingly, the State administration took measures to find out the cause of the trouble. As the only change appeared to be due to the carrying out of the hydraulic work, it was thought that the rise in the level of the watersoaked part of the soil was the direct cause of the falling off of the cotton production, and to verify this, the commission made a series of tests by growing cotton plants under conditions which were the same as usual except that artificial means were provided for keeping certain soils at ranges of 2 to 10 feet depth for the watersoaked layer. For each portion the depth was kept constant. The results of the tests clearly showed the great influence which the water depth had upon the cotton crop. The yield of cotton in each piece of ground is constantly proportional to the depth of the underground water and is better, as the watersoaked layer lies farther below the surface. At present the commission is engaged on tests in order to show what are the best conditions for cultivating cotton as well as other Egyptian plants. These results will be of value in many other cotton-producing countries.

In Europe there has been employed a novel method of exploding mines based upon the action of sound-waves. It is known from laboratory experiments that if a disk which is free to turn about its diameter is placed inside a cylindrical resonator, and the fundamental note is sounded, the disk will place itself in a plane perpendicular to the cylinder. By causing such a turning disk, governed by sound-waves, to complete an electric circuit, it would be possible for a warship to explode a mine by giving a certain signal on a siren, tuned to the same note as that of the resonator.

The Progressive Disclosure of the Entire Atmosphere of the Sun*

By Prof. H. Deslandres of the Meudon Observatory

THE sun, to which this paper is devoted, is a magnificent subject of study. All men feel more or less clearly that terrestrial destinies are closely bound up with those of the sun, and that it is necessary to investigate its particular nature, its total radiation, its variations and, in a word, its exact and complete effect upon our globe. Our dependence upon the sun is absolute, and recently this has been summed up in a very simple manner by a French politician, now minister of finance. To him is due especial credit for the Meudon Observatory, which I direct, and for the solar researches there pursued. At first he refused to consider the matter, pleading in excuse the continued increase of the public expenses. Then, as I became more urgent, he exclaimed: "You are right, the sun is '*notre maitre*,' the master of us all. It is impossible that we should not do something." It is thus that the Meudon Observatory has been able to add to its ordinary budget a supplementary sum, not large, to be sure, but coming at an opportune moment, and rendering great assistance in the researches which I am now able to present.

The modern study of the sun requires a costly equipment, complicated apparatus and an observer especially fitted for physical as well as astronomical observations. Now the sun shines for all the world, and ripens all the crops, *à priori*, it seems natural that all the men of this planet should co-operate in solar research. In accordance with this idea, I proposed some years ago to the Astronomical Society of France a very small special and general tax for the sun. If each Frenchman, said I, would give one sou, one single sou, for the sun, the sum total would be large. It would be sufficient to guarantee the maintenance of a continuous record of the sun and its variations—a record not yet realized—and therefore a more profound knowledge of this star. But new taxes are ever being added on to us, and this one, although very light and perfectly legitimate, would probably be repudiated. Moreover, it may be said that the individuals of civilized nations, especially those who live in towns, concern themselves very little with the sun. They have less regard for it than the primitive man and the savage who have neither watch nor almanac. The realization of this plan is reserved for the future city, and for a social state more perfect than ours.

Recourse to the government, to the people as a whole, is a French custom. It would be better, as in England, to appeal to a private initiative, to the initiative of enlightened and generous men. It is thus that the Royal Institute was founded, an institution which has witnessed the development of so many beautiful discoveries and the rise of so many illustrious savants. This fine example ought to be cited to all, and we may say that it has been largely followed in America, where the greatest of observatories, and especially those devoted to the sun, have been founded by private individuals.

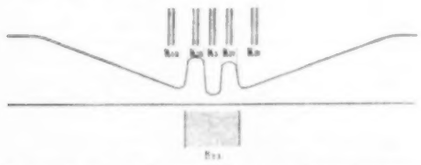


Fig. 1.—Curve of the Intensity of the Solar Spectrum in the Region of the Broad Band K. The Shaded Areas Represent the Different Positions of the Slit of the Spectroheliograph

In fact, in the last fifty years, thanks to the help of governments and of men of wealth, the study of the sun has made considerable progress. Astronomers have devoted to it a serious and permanent organization and have even extended it to the entire atmosphere of the star, a region hitherto inaccessible.

The principal discovery which has been made in regard to the sun is the periodic variation of its black spots, a variation which is manifested also by the brilliant faculæ of the sun's surface and by the entire atmosphere, which extends out to a great distance. The sun as a whole has one great general oscillation, and what is even more remarkable, this oscillation extends to the earth, at least to its magnetic elements.

The extension of this solar phenomenon to the earth is of great importance. It implies, almost necessarily, a hitherto unknown special action exercised by the sun upon our globe. This is the first cause of the great favor in which solar research is now held. Since the discovery by Sabine and Lamont of the connection between terrestrial magnetic variations and

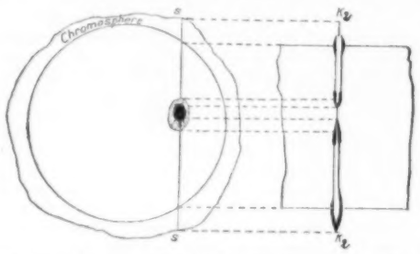


Fig. 2.—(Diagrammatic) ss, Section Through the Sun in the Plane of the Spectroheliograph Slit. The Chromosphere and Spot are Greatly Magnified. K_2, Brilliant Line Attributed to Calcium Vapors, and Appearing at the Center of the Dark Band K of the Normal Spectrum. This Line is Single and Sharp Over the Spots, and in the Upper Parts of the Chromosphere, and is Double at Other Points, Being Divided in Two by the Central Dark Line K_3

solar phenomena, English science has paid great attention to sun spots, and England was the first to organize systematic photographic observations of the sun spots and magnetic elements at several different points on the earth, and to concentrate all of these observations at one observatory, which has discussed them with great precision. The labors of Ellis and of Maunder in this field are well known, and it is well also to recall the works of Lockyer and of Schuster who have recently recognized, in the variations of sun spots, periods both larger and shorter than the principal eleven-year period.

The action exercised by the sun upon the earth is generally attributed to the spots, but it may have its origin in the solar atmosphere, which has the same period of variation, hence the necessity of studying and investigating this atmosphere with care.

Now for almost twenty years I have devoted myself to the investigation of the entire atmosphere of the sun and I shall present to you herewith the most recent results in connection with the higher layers of this atmosphere, hitherto unexplored.

ATMOSPHERE OBSERVED DURING ECLIPSES AT THE EDGE OF THE SUN.

The atmosphere of the sun revealed itself to man for the first time during total eclipses at the edge of the sun's disk. It forms at that time a luminous ring, bounded on the outer side by the black sky and surrounding the disk of the moon, equally black. It comprises two distinct parts, starting from the moon or the edge of the sun; the *chromosphere* thin and brilliant, of a rose color, from which arise the *prominences*, likewise rose colored, and then the *corona* much paler but of great extent. In what follows the attention will be confined to the chromosphere and prominences. In ordinary times the luminous ring seen during eclipses is concealed by the more intense illumination of our sky. The screen which hides it is luminous. In order to remove this screen, the English astronomer, Sir Norman Lockyer, in 1866, conceived the idea of making use of the spectrum, adopting the quite probable assumption that the solar atmosphere was gaseous. That was the idea of a genius who has since made his mark.

The eclipse of 1868 showed, in fact, that the red prominences are composed chiefly of incandescent hydrogen, which emits the radiations already recog-

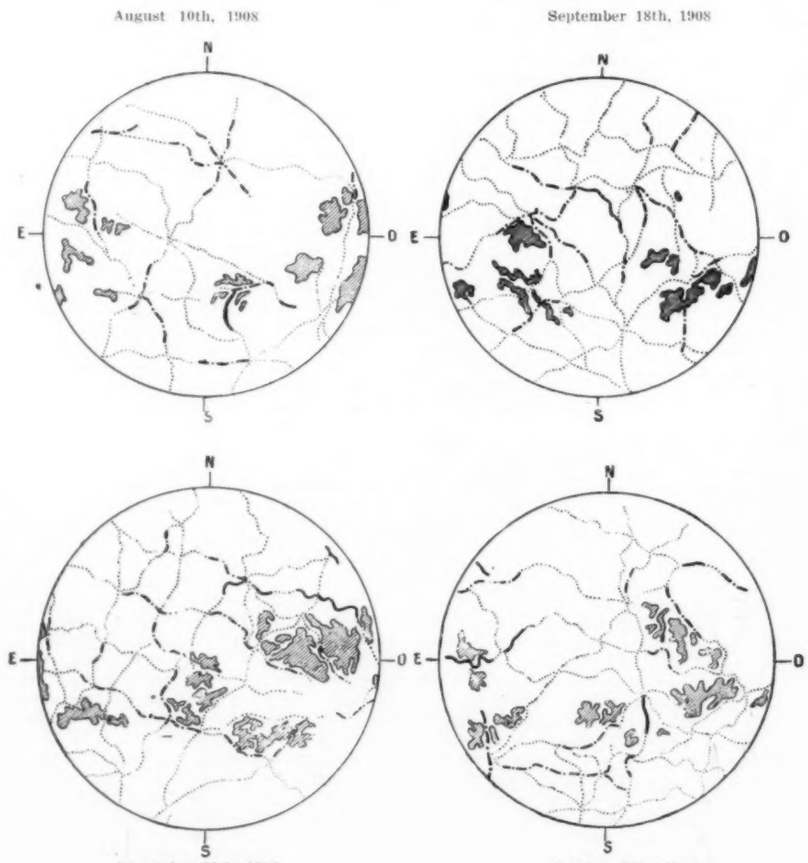


Fig. 3.—Net Work of Line Markings Observed in the Upper Layer of the Solar Atmosphere. The Full Black Lines Correspond to the Sharp, Continuous Markings, Known as *Filaments*. The Broken Lines Represent Similar but Less Sharp Markings, and the Dotted Lines Correspond to Still Fainter, and Partly Discontinuous Markings. The Shaded Areas Show the Location of the Largest Bright Faculæ

* Discourse delivered at the Royal Institution of Great Britain, June 10th, 1910. Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Nature*, with illustrations from the Annals of the Paris Observatory.

ized in the laboratory under the influence of the electric spark, and in particular an intense red ray called $H\alpha$. After the eclipse, Janssen, in India, and Lockyer, in England, with the spectroscope and the red hydrogen ray, again found the prominences and the chromosphere seen during the eclipse. This result excited a legitimate enthusiasm, for the method so simple, yet so fruitful, has been used for the past forty years in the daily study of the chromosphere and of the positions and forms of the prominences. This study is even more fascinating than that of the spots, for the prominences have the most varied forms and exhibit the most rapid changes. They appear in all latitudes, and also follow the eleven-year period of the spots, the duration of the maximum being, it is true, somewhat longer.

The spectral study of the edge of the sun, carried out in ordinary times, or better during eclipses, has also revealed the chemical composition of the chromosphere and the height of each vapor, determined by the lengths of the corresponding lines in the spectrum.

In a general way the vapors of elements of small atomic weight and of the light gases rise to the greatest height. Such is the case with hydrogen and helium. The spectral line of these two gases which rises to the greatest height is the red $H\alpha$ ray of hydrogen. The other hydrogen lines diminish both in length and intensity from the red to the ultra-violet.

But the highest of all are the brilliant violet *H* and *K* lines which are emitted by the compounds of calcium. As the atomic weight and the density of calcium vapor are both relatively high, this would appear strange, but it is easily explained according to Lockyer by a dissociation of calcium in the sun and in the electric spark of our laboratories. The *H* and *K* lines (in all respects exceptional) are very brilliant at the edge of the sun, and thus render easy the photography of prominences with ordinary plates.

On the other hand, the heavy vapors, which are by far the more numerous, rise only to a small height in the atmosphere, and are easily visible only during eclipses. They form the relatively brilliant lower layer of the chromosphere called the *reversing layer*.

CHROMOSPHERE PROJECTED UPON THE DISK, MIDDLE LAYER.

Such are the principal results of the Lockyer-Janssen method. They are surely remarkable, but in certain respects incomplete. They apply only to that part of the chromosphere outside the edge of the sun, and only to the light vapors which rise from the edge. The part within the edge, that is, projected upon the disk, fully fifty times greater in extent, escaped them.

Now this gap was filled in from 1892 to 1894 by a perfectly general method which disclosed all the vapors high and low, and their successive layers in the entire hemisphere turned toward the earth.

At the edge of the sun the rays of these vapors stand out bright against the continuous spectrum of our sky, but upon the disk these lines appear as dark bands, as is well known, and the continuous spectrum which serves as a background is the spectrum of the sun itself, which is much more intense. *A priori* the difficulty appears very great.

The calcium lines *H* and *K*, however, form an exception to this rule, and this fact was announced simultaneously in February, 1892, by Hale and Deslandres. These lines are very broad, indeed the broadest in the solar spectrum, but at points on the surface where there are faculæ, they are reversed; that is to say, they show in their centers a double bright line which, in fact, appears double not only in the dark band, but also in the bright line of the prominences outside the edge of the sun. (See Fig. 1, which shows the ray *K* and its components K_{1r}, K_{2r}, K_3, K_{2v}, K_{1v}).

The result has been obtained by Hale with a spectroheliograph, a new and very complicated apparatus which isolates a radiation by means of a second slit, and by the movement of this luminous slit produces a monochromatic image of the sun. For my part, I used an ordinary, simple spectrograph and successive sections of the sun, thus paving the way for the use of the spectroheliograph.

In the mean time the two observers were disagreed as to one important point. Hale located the vapors thus revealed in the faculæ upon the surface; I, on the contrary, located them outside in the atmosphere.

Now the ordinary spectrograph which combines all the elements in question furnishes a general solution of the problem. It is from this point of view superior to the spectroheliograph.

The double line K_2 is brilliant, not only upon the faculæ, but also upon all other points of the disk, where it is, to be sure, somewhat weaker and more difficult to distinguish. Moreover, the bright double K_2 is always sharp just inside the edge of the disk and is prolonged outside the edge by a bright double line. (See Fig. 2, which shows diagrammatically the aspect of the double line K_2 at the edge of the sun, and upon a spot.)

As the K_2 line outside the edge of the sun represents by definition the chromosphere, it follows that a picture in the light of the K_2 line with the spectroheliograph represents the entire chromosphere projected against the disk.

Moreover, the calcium pictures made at Paris in 1894, which were the first complete pictures, show the bright faculæ larger than upon the ordinary surface photographs, and they also show the smaller bright areas, now called flocculi, which are seen at the poles as well as at the equator. I have verified the presence of flocculi at the poles in the years of the sunspot minimum and during the whole of the eleven-year period.

The bright K_2 line remains double outside the edge up to a height of 4 or 5 seconds, and as the chromosphere at the edge has a height of 10 seconds, we may say that the image in the light of the K_2 line represents the mean chromosphere.

To sum up, the first spectroheliograph to give results was constructed in America, but it was in France that the entire chromosphere of the sun was first recognized.

THE SHALLOW CHROMOSPHERE.

But we may go still farther. In 1893, I announced that the isolation of an ordinary dark line with the spectroheliograph would give an image of the corresponding vapor, and, in 1894, with a small spectroheliograph of weak dispersion, I isolated the low edges of the *K* ray, called K_{1r} and K_{1v} and the neighboring dark lines of aluminium, iron, and carbon. The images obtained differed from that of K_2. The

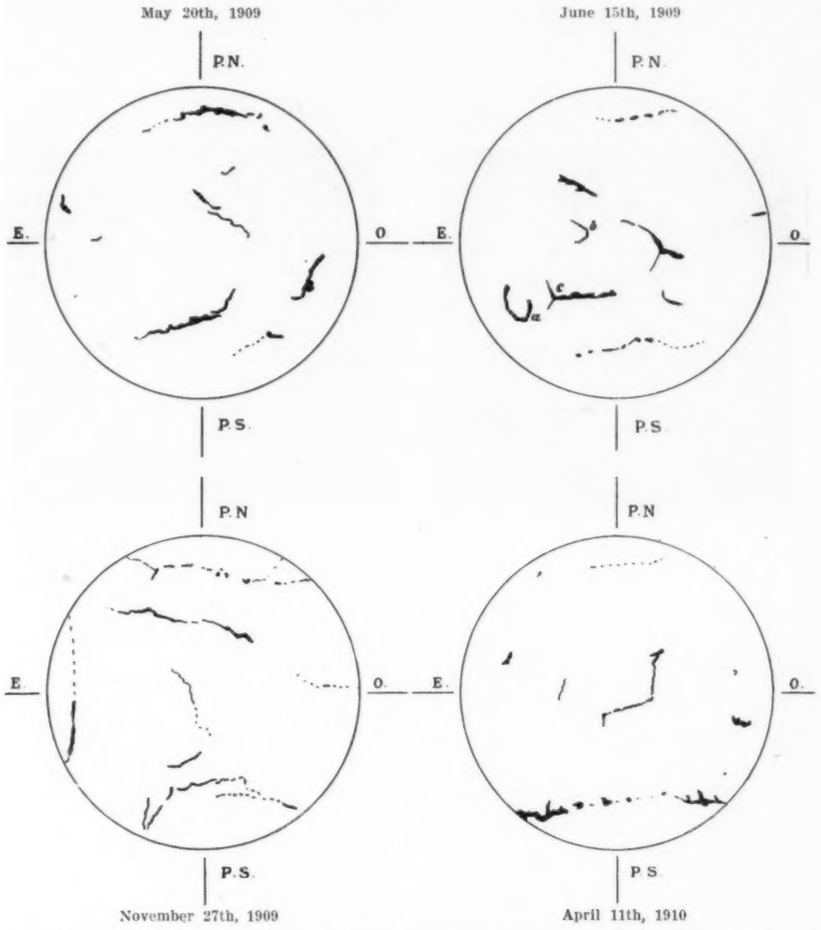
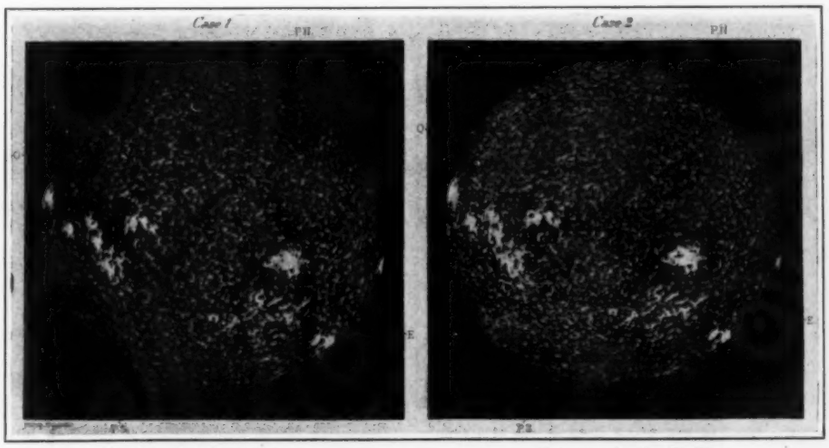


Fig. 4.—Image of the Highest Layer of the Solar Atmosphere, Showing the Characteristic Black Filaments and Especially the Polar Filaments. Taken in the Central Part of the Hydrogen H Line, or in the Calcium K. These Views Show Only the Filaments Without the Alignments



Exposure in the K_3 Line — Exposure in the K_2 Line

Fig. 5—Views of the Sun Taken on September 18th, 1908. The View in K_3 Shows at the Center a Fine Example of a Filament

spots which are at times partly obscured when photographed in the light of K_3, always have their umbræ and penumbræ very sharp when photographed in these other rays. The faculæ are bright at the center as at the edge, but smaller than in the K_2 images. In fact this new image given by the K ray or the rays of aluminium, iron, carbon, etc., is intermediate between the image of the surface and that of the mean chromospheric K_3 layer. It represents the entire reversing layer which was thus obtained for the first time.

A greater dispersion would permit the isolation of the fine lines which are so numerous, and especially of the narrow central dark line, K_3, between the two components of K_2. This line corresponds to the highest layer of the atmosphere. This method is therefore absolutely general. It furnishes the images of all the solar vapors, and also the images of their successive, superposed layers, at least, when the line is divisible into distinct parts as in the case of the large K ray.

Now the number of lines in the solar spectrum amounts to about 20,000, and, according to Jewell, all the lines present in some degree the same special constitution as this typical calcium line. This opens to investigation a new field of vast extent.

FURTHER RESEARCHES. GREAT SPECTROHELIOGRAPH OF A NEW TYPE.

The programme of research marked out in 1894 was therefore most elaborate. It has been carried out in part in the ensuing years, and the progress has been real if not very rapid.

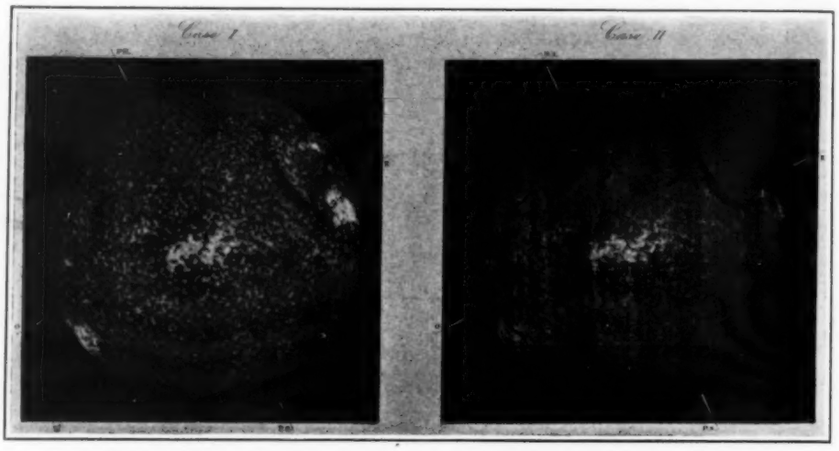
In 1903 Hale and Ellerman, at the Yerkes Observatory, took up again the study of the dark lines with a spectroheliograph of greater dispersion, and since 1906 they have continued this study with still more powerful instruments at Mount Wilson. They have obtained magnificent pictures and a large series of new facts. With the lines of the reversing layer the results are about the same as those obtained in 1894, but the hydrogen lines and very recently the $H\alpha$ line have shown some new and very curious phenomena, which we shall discuss more in detail.

Although they have used only moderate dispersion they have isolated a somewhat greater number of lines than were isolated in 1894, but none of the very fine lines. And even in the cases in which they have been successful, they have isolated the line as a whole. They have not separated the line into its distinct parts and obtained images of the successive layers of the vapor. Their image is a composite of several distinct images corresponding to different layers.

I propose to fill in this gap in the investigation and carry out the programme of 1894 and isolate completely the highest layers which have not yet been revealed. Since becoming director of the Meudon Observatory in 1907 I have been able to direct the resources of the Observatory, and we have been fortunate in obtaining extensive credit which has rendered it possible to construct a great spectroheliograph as dispersive as the great spectrograph of Rowland, and a large special building to contain it.

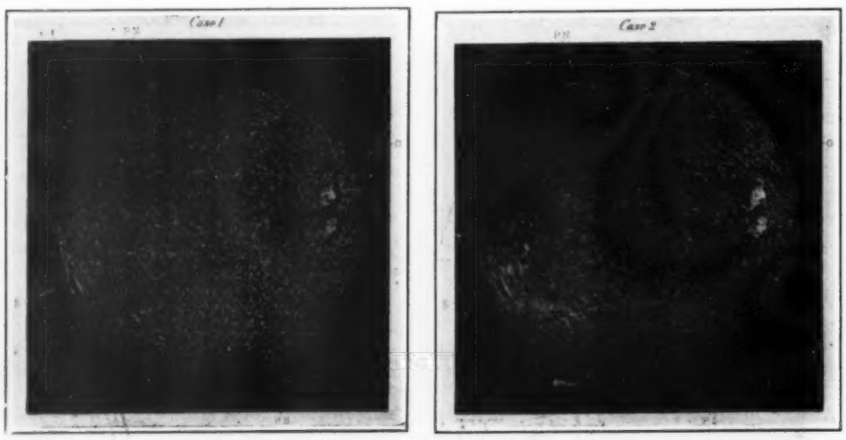
The building covers an area 22 meters by 6 meters. Its roof is of stone and earth which assures a constant temperature in the interior. It receives the light of the sun from a coelostat at the south, constructed from the old transit of Venus apparatus, and an old objective of 25 centimeters aperture, and four meters focal length. These pieces of apparatus, which are only mediocre in quality, have been used for the sake of economy. The spectroheliograph on the other hand is of a new type, and possesses several interesting characteristics. It is somewhat complicated, at least in design, for it comprises four spectroheliographs combined with one collimator. The first is an instrument with three prisms and two slits, with a length of three meters, giving an image of the sun 85 millimeters in diameter; the second has a grating and two slits, and is of the same length. The third has an entirely different arrangement from the two preceding, and the fourth, the most powerful of all, has three slits, and may be used with prisms or gratings. It comprises first a spectrograph of seven meters length, as in the classic apparatus of Rowland, which permits the isolation of very fine lines. But the solar image requires too long an exposure; we therefore insert a second spectrograph which diminishes the size of the image to any desired degree, and at the same time, eliminates the interior diffuse illumination. The final image of the sun has a diameter which can be anything whatsoever, and thanks to a certain special arrangement of the apparatus the image is complete, a result which is not realized in the other spectroheliographs of high dispersion. The diameters ordinarily used are six centimeters and our centimeters.

The apparatus, with the two spectrographs, has a total length of 14 meters, and in this arrangement remains immovable. It is the first spectroheliograph to be constructed, all of whose parts are fixed, except the plate. The movable parts are the photographic plate and the astronomical objective, which are moved at any desired rate by synchronized electric motors and transformers for special speeds. The agreement of the motions is assured by electric means, independent of distance, and this arrangement is presented as a general solution of the spectroheliograph. Each of the four spectroheliographs has its especial advantages, and the passage from one to the other can be made in a very few minutes. The observer thus has at his command the means of carrying out various investigations. In a general way the three-meter spectroheliograph with two slits gives a larger image, richer in detail. The great 14-meter apparatus with three slits gives, with a longer exposure, a much smaller but much purer image, and it permits the isolation of the very fine lines.



Exposure in the K_3 Line — Exposure in the $H\alpha$ Line

Fig. 7.—Views of the Sun Taken on March 21st, 1910, Showing Filament, Faculæ, and Solar Vortices in the Faculæ



Exposure on the Violet Side of the $H\alpha$ Line — Exposure in the Central Part of the $H\alpha$ Line

Fig. 6.—Views of the Sun Taken September 11th, 1909. These Two Views Clearly Show the Difference in the Two Hydrogen Line Images, the One Corresponding to the Middle Layer, the Other to the Upper Layer

The researches with this apparatus have been carried out with the assistance of a young astronomer of the observatory—M. d'Azambuja, whose name is associated with mine.

DISCOVERY OF THE K_3 HIGHEST LAYER OF CALCIUM.

In 1908 we were able to isolate the small central dark band, K_3, of calcium, and thus photographed the highest layer of calcium. Fig. 1, which shows the K ray and its components, will enable one to judge of the progress realized.

Up to that time the spectroheliographs employed isolated only the combination of the two bright K_1 components which inclose the K_3 ray. For this a slit wide enough to include 90/100 Angström units of the spectrum was used. The resulting image, called by us the K_{13} image, was a composite of the K_3 and K_1 layers with a predominance of the brighter K_1, by which the highest K_3 layer was rendered inconspicuous. Now with the great spectroheliograph, with a slit width of only 3/100 Angström units, we have been able to isolate easily, not only the K_3 ray, but also the K_2, and to have the image of each layer perfectly pure and free from all extraneous light. The corresponding positions of the slit are indicated in Fig. 1 by the shaded bands.

The vapor of calcium, which at the edge of the sun rises higher than any of the other vapors, presents, as we have seen, three distinct superposed layers. If we add the surface, we have four layers, which it will be interesting to compare.

Starting from the surface and going up, the faculæ or bright areas increase in extent and in relative brightness. The middle-sized flocculi also increase, while the small ones disappear or become scarcely visible. The result is a characteristic appearance of the K_3 layer, which at a glance distinguishes it from the K_2 layer, photographed since 1892. (See the two K_3 and K_2 photographs of September 18, 1908, Fig. 5.) I may add that the peculiar network of flocculi, called by me in 1894 the *chromospheric réseau*, which often covers a considerable area with polygons having their sides and vertices in juxtaposition, is in general, sharper in the highest layer.

On the other hand the black spots, which are the chief characteristic of the surface, diminish as one goes up, and may even disappear.

There appear in the highest layer some black lines which are invisible in the lower layers. They are often very long, and have been called by me filaments. In general the filament is continued in both directions out to the edge by other lines less black, and less sharp, called alignments. The combination of the filaments and alignments forms a regular network over the disk of the sun. The filaments and alignments are a new phenomenon, characteristic of the highest layers.

The filament has the same importance as the spot on the surface. It persists like the spot through several rotations, and like the spot also, it is the seat of special disturbances, and is accompanied by prominences.

In my first studies I have likened the spots to the barometric depressions or cyclones of our atmosphere, and the filaments to the anti-cyclones. I shall return again to this comparison and develop it more fully.

DISCOVERY OF THE HIGHEST LAYER OF HYDROGEN.

The following year, 1909, d'Azambuja and I, with the same apparatus, studied the hydrogen lines, and especially the red $H\alpha$. These lines had already been isolated by Hale and Ellerman, who obtained very curious results. In 1903 they discovered that with

Hβ, *Hγ*, and *Hδ* the faculæ are not brighter as in the case of the calcium lines, but, on the contrary, they are often dark. With the Hα, isolated in 1908, one generally finds all around the spots a series of fine lines, which generally give a distinct impression of a vortex. Most of these *Hα* images are beautiful and very rich in fine detail.

However, these American *Hα* photographs were obtained by isolating the spectral band as a whole, and I announced in 1908 that they ought to be a composite of two or three images of distinct layers. In fact, according to Rowland, the *Hα* band is doubly reversed just like the calcium *K*, but much weaker. The width of the *Hα* line, including its lower parts, is 1.24 Angström units; without these parts 0.90 Angström units. We ought therefore to expect some slight differences in the images when the different parts of the line are isolated.

Now we have verified completely this fact, and, indeed, contrary to our expectation, the differences between the hydrogen images are relatively greater than with the calcium.

The exact results are as follows: If one isolates in *Hα* the lower part near the edge, corresponding to the K_1 of calcium, for a distance from the center comprised between 0.47 and 0.62 Augström units, the result of 1909 will be obtained; that is to say, the faculæ will be dark with respect to the background.

With the middle of each part, between the distances 0.10 and 0.42 Augström units from the center, the image is quite different. It presents the chief characteristics of the American photographs of 1908, and especially the groupings of fine lines which Hale has called the solar vortices.

Finally, with the center of the band, we have a third type of image, different from the other two, much weaker and less complex, an image which corresponds to the highest layer of hydrogen.

Now, and this point is important, this new image shows the same black filaments as the K_3 layer of calcium. As for the faculæ, in this image, they are never black, but are bright. They are less extensive than with K_{2v}, and correspond to the brightest portions of the bright areas in the K_{2v} portions which differ from those of the K_2 and K_1 layers. The darkest parts and the brightest parts coincide in position. (See the corresponding K_3 and *Hα* photographs, obtained September 11th, 1909, March 21st, and April 11th, 1910, Figs. 6, 7, 8.)

Moreover, we have isolated also the different parts of the blue *Hγ* line of hydrogen, which rises to a much less height in the solar atmosphere than the *Hα* ray, and we have obtained images which show the faculæ almost exclusively in black, just as in the lower part of the red *Hα*, and which therefore correspond to a low level.

Finally, we are forced to conclude that the hydrogen, as well as the calcium, presents three distinct superposed layers, which have now for the first time been clearly separated.

Moreover, in what precedes, I have explained the different parts of the same band, and the different images by the ordinary action of emission and absorption in the gas, assuming, as is natural, that the density of the gas and the width of the band diminish as the height in the solar atmosphere increases. But it has been objected that anomalous dispersion can also have some effect, and can explain, at least in part, the peculiarities of the images. Now, in my opinion, anomalous dispersion certainly ought to enter, but to a very slight degree, and is negligible in a preliminary investigation. The arguments in support of this assertion would require too much space to develop here. Moreover, even if anomalous dispersion has been discovered, in the laboratory, in the *Hα* line of hydrogen, it has not as yet been proved in the case of calcium. Further, as the center of the band does not undergo anomalous dispersion, the objection does not apply to the highest layers, with which we are especially concerning ourselves here.

The black filaments, which appear both with the calcium and the hydrogen, form a characteristic element of the highest layers. Some of these were suspected by us and some mentioned by Hale in connection with the early complex images of *K* and *Hα* under the name of long black flocculi, and were considered as probably to be associated with the higher layers. In fact, under these conditions, the most important filaments, which correspond to the broad dark bands, are generally obtained, but the complete investigation of the filaments and their characteristics can be carried out only in connection with the images of the highest layers.

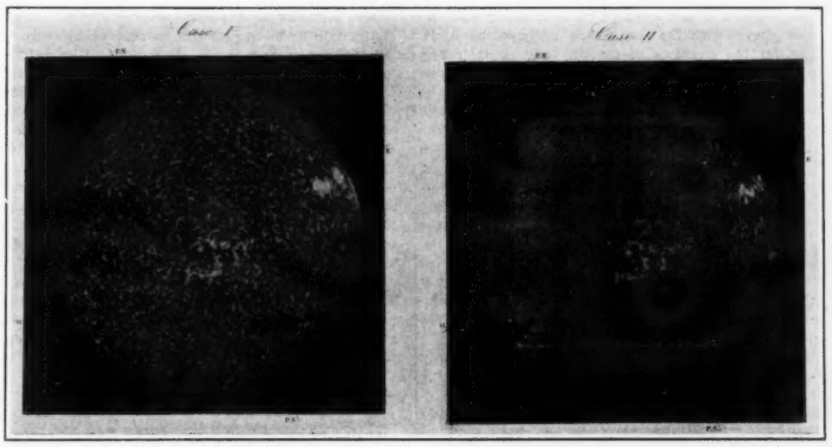
Another important element in these latter layers is the bright faculæ which are found in the same positions as those upon the surface, but of different shape.

To sum up, then, if we consider the four layers formed by the surface and the atmosphere, the brightest parts are found over the faculæ. The darkest features, however, have quite different positions upon the surface and in the highest layer. Below are the spots; above are the filaments which have a black surface area greater than that of the spots. The area of the filaments can easily be measured just as accurately as that of the spots.

RESEARCHES UPON THE MOVEMENTS OF THE ATMOSPHERE. SPECTRO-RECORDER OF VELOCITIES.

The dark filament attracts especial attention, and, as has been said above, it has an importance at least equal to that of the spots. What is then the origin, what is the nature of these long black lines? An exact answer is indeed difficult, and in this connection we may recall our lack of precise knowledge of the sun spots which have been studied for three hundred years. However, in the case of the filament, the investigation may be easier. The surface, in which the spots are located, is included between the interior of the sun, which is entirely unknown to us, and the lower complex layers of the atmosphere. But the highest layer, in which the filaments are located, is more free and open, and may have a structure less complex, and simpler movements.

In Meudon we have recently obtained some most interesting results in regard to the filaments by means of a special apparatus, the only one of its kind thus far constructed, which might be called the spectro-recorder of velocities. This instrument, which I have used since 1892, was greatly improved in 1907. It reveals, as its name implies, the radial movements of the solar vapors, by juxtaposing small portions of the spectra of successive equidistant sections of the solar disk. This is accomplished by using a wide second slit and an automatic discontinuous movement. This speed-meter is a necessary complement of the spectro-heliograph and is at least as useful. It reveals, in addition to the radial velocities, the general forms of the vapors, the details of the entire line, and especially the width of the line isolated, a width very variable from one point to another on the sun. It reveals points not shown by the spectroheliograph, for the latter cannot, with a slit of constant width, isolate exactly a line of variable width. In a word, it registers all the elements which escape the spectroheliograph and permits a sure interpretation of its results.



Exposure in the K_3 Line — Exposure in the H_α Line

Fig. 8.—Views of the Sun Taken on April 11th, 1910, Showing Filaments and Polar Curve

Upon the plates obtained with the *K* ray, an examination with the naked eye shows at once that the radial movements are in general more noticeable upon the filaments than upon neighboring points. Frequently all the K_3 rays of a filament are inclined in the same direction. This indicates a vortex with an axis horizontal as opposed to the vortex with vertical axis, which is acknowledged to exist in connection with spots. Moreover, this agitation is followed by a relative calm, just as in the case of the spots. If we measure with care the displacements and radial velocity of K_3 near the center of the sun we find that the vapor is ascending with a velocity often greater than the equatorial velocity of rotation (say 2 kilometers per second). This fact has been verified upon several filaments. In regions away from spots and filaments the vertical velocities in the highest layer are conspicuous and often of the same order as the equatorial velocity of rotation. The magnitude of this vertical movement is less astonishing when it is noted that the mass of gas which forms the atmosphere rests upon an intensely hot surface.

Analogous measurements have been carefully made at the center of the sun upon faculæ and flocculi, and the result has been just the reverse. The bright vapor has a descending motion while the relative dark areas near by are ascending. In general, at bright points of the K_3 image of the highest layer the vapor is descending; where the image is relatively dark the vapor is ascending. This is perfectly logical, for the descending vapor is becoming compressed and heated, while the ascending vapor is expanding and cooling.

This phenomenon, already detected upon a great many plates, is important, for it explains the special structure of the atmospheric layers, which appear as if divided by convectional currents just like liquids in the laboratory when heated uniformly at the bottom. The bright flocculi often form over a wide area distinctly outlined polygons joined at their vertices, and very similar to the polygons which form the vortex cells in liquids, so well studied in France by Besnard.*

As the vapor descends upon the bright flocculi and rises in the spaces in between, each solar polygon thus becomes a vortex cell. As to the other flocculi on the same image, they show less marked polygonal shapes, or even, though more rarely, have forms which are wholly irregular.

On the other hand, the filaments and alignments probably form the boundary of larger cellular vortices superposed upon those previously formed in the upper layer which have the spots for their centers. This conception is in accord with the movements of this layer in the vicinity of spots discovered by the English astronomer Evershed. We can thus easily explain why the spots are points and the filaments lines, sometimes very long. The question involved in these researches is therefore already partly answered. The problem will be completely solved, I believe, by the systematic measurement of radial velocities, extending these measurements to the entire disk of the sun, a process unfortunately involving long and tedious labor.

INVESTIGATION OF POLAR FILAMENTS.

I will close by mentioning a new property of filaments recently discovered at Meudon. The observatory already has plates of the upper layer of the atmosphere for more than twenty completed rotations of the sun, and from these it is possible to study the distribution of the filaments. They appear in all latitudes, but especially around the poles; they are grouped upon a curve more or less circular, surrounding the pole but often not concentric with a parallel. This polar curve of filaments is at times sharply defined at both poles, but in general it appears only at one pole and changes from one pole to the other. This polar curve was particularly strong around the south pole last April. (See the two photographs of April 11th, 1910, Fig. 8 and Fig. 4, which represents the filaments on four different days.)

The polar filaments are accompanied by prominences and agree in position with the secondary maxima of prominences which have already been noted near the poles. They may also have some relation to the peculiar form of the solar corona near a sun spot minimum, and to the fact often noted, that the axis of the corona is inclined to the axis of rotation.

At times the polar curve is accompanied on the side towards the equator, by a line of parallel filaments which is joined to the curve by inclined filaments or alignments. We have thus an arrangement analogous to the belts of the planet Jupiter.

Finally, the polar zone of filaments, where the vapor,

* This arrangement of adjoining polygons is at times very distinct over the entire disk of the sun. The K_3 plate of September 18th, 1908 shows in the southern hemisphere, near the center, some of these polygons united at their sides and vertices, but a sharper and larger image is necessary in order to see them well.

as we have seen above, is ascending, may be connected with the zone of spots and faculæ in the vicinity of the equator, where the vapor is descending. We are led to infer in the upper region of the atmosphere a great meridianal circulation, a great general convectional current, analogous to that which exists upon the earth in each hemisphere between latitude 35 degrees and the pole.

The time unfortunately is too short to develop all the consequences of these first observations. The facts presented will suffice to show the great interest in the study of the upper regions of the solar atmosphere and the great necessity of continuing them.

The solar atmosphere is the only atmosphere we can study as a whole, and in its successive layers. Our recording apparatus will give in a few minutes its general aspect and its principal movements. From this point of view the solar atmosphere is better known to us than the atmosphere of the earth, for we can observe only the lower regions of the latter and those only over a limited area even with the aid of the telegraph.

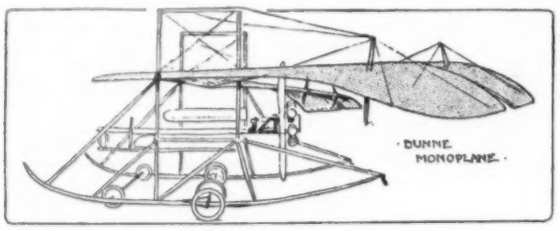
The network of convectional currents and curious filaments discovered in the upper regions of the solar atmosphere may exist also on the earth, and it is thus that the study of the sun may teach us to understand better our own atmosphere.

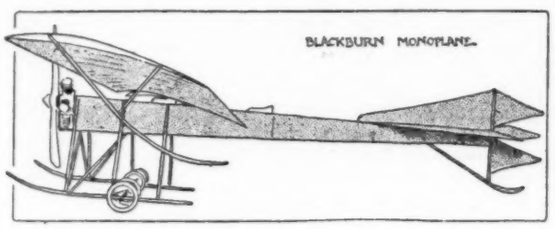
More Aeroplanes at Olympia*

With Special Reference to the Dunne Monoplane

WE publish herewith details of the Maurice Farman and Humber biplanes, and the Blackburn, Piggott, Dunne and Nieuport monoplanes.

The two biplanes, as may be observed, afford rather an interesting comparison, because they both embody in their construction the characteristic Sommer type



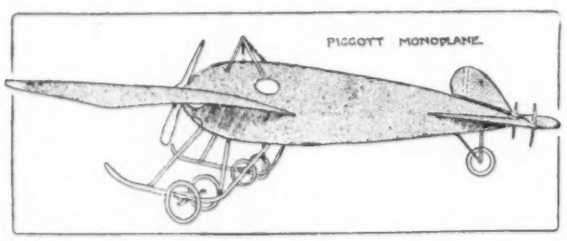


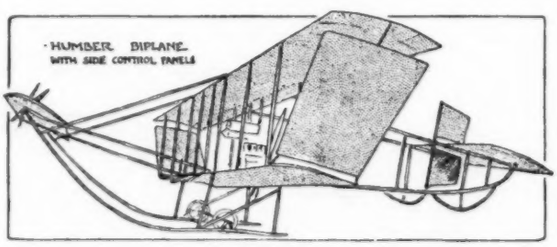
forward outrigger, in which the skids are carried up for the support of the elevator. The Humber machine is also shown with the side panels designed by A. H. Bailey for the purposes of stability and control, who also exhibited this system in the model section. The object of these panels is to confer the principle of the dihedral angle and to act partially as rudders and partially as screens, as was done on the Neale biplane which we recently described, and the details of which will be fresh in the minds of our readers. The panels, it will be observed, are attached at their lower corners by cords to the lower main plane, while a single cord attaches the center of the upper edge of the panel to the upper main plane. By this means the panels can be skewed or warped into any desired position, and the control attachments are such that similar or opposite movements may be made simultaneously in the two panels, according to the effect required.

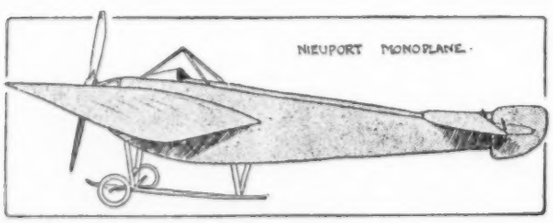
Among the monoplanes, that which will probably attract the greatest interest among our readers is the Dunne. The Dunne monoplane, like its prototype biplane, is designed to possesses natural stability, and is tailless in the ordinary sense of the term. In principle, however, the V-plan form of its wings gives it two tails instead of one, and the hinged flaps in the trailing extremities of the wings provide it with two elevators instead of one. These flaps are under independent control, and serve the purpose of steering the machine horizontally and vertically. The principle of stability associated with the Dunne monoplane is somewhat complicated, and has to do entirely with the special formation of the wings, which are generated on the surface of a cone. This is not the place in which to go into precise details of this method; but it will be interesting to learn that the apex of the cone is altogether in a different place, being situated, on the monoplane, a little way behind the trailing extremity of the wing and more or less directly in line with the outside edge. This formation of the wing gives a variable angle of incidence from shoulder to tip, which, in conjunction with the V-plan form, confers on the machine the principle of the fore-and-aft dihedral angle, which is one of the accepted methods of obtaining natural stability and is a characteristic feature in the design of all successful aeroplanes. Owing to the wing extremities being situated in an exposed region and not sheltered behind the middle portion of the plane, as is more or less the case with the tail of an ordinary aeroplane, Mr. Dunne claims that their tail effect is enhanced. Also the same argument applies to the efficacy of the dihedral angle, because, owing to the formation and continuity of the wings, it is impossible to define what part constitutes main plane and what part tail. That in fact the relative functions of these members are performed by different parts of the wings in accordance with the requirements of the moment.

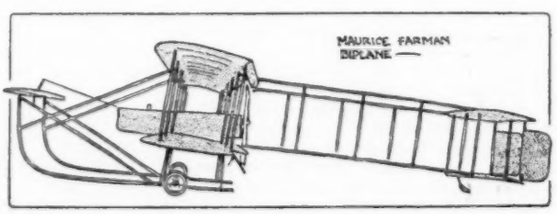
Lateral stability in the Dunne monoplane is somewhat more difficult to explain, but that which is the most significant feature in the design is unquestionably the fact that the wing formation provides downturned wing tips as distinct from the upturned wing tips on such monoplanes as the Handley Page and Weiss, which are also designed more or less with a view to natural stability. It will be noticed, of course, that it is the leading edge of the Dunne monoplane that is turned down, whereas in the Handley Page and Weiss monoplanes it is the trailing edge that is turned up, so that the relative positions of the leading and trailing edges in all three machines are identical. On the other hand, it will be observed that there is a very material and fundamental difference in principle between the two methods, for whereas in principle the upturned trailing edge represents the lateral dihedral angle, the down-turned leading edge represents the gull's wing, which is an accepted method of obtaining lateral stability in side gusts. The general action is as follows: A side gust ordinarily lifts that side of the machine against which it first strikes, because of the aeroplane action of the planes considered in their attitude toward the gust and the consequent travel of the center of pressure toward the virtual leading edge facing the gust, which involves an actual travel of the center of pressure laterally from the real center of gravity of the machine. Thus the machine cants over and the upset is emphasized with the dihedral angle, because the upturned wing offers an increasing surface for normal pressure. In the gull's wing method the remoter down-turned wing tip presents the more effective surface to the gust and tends to counteract the lift due to the travel of the center of pressure on the remainder of the plane. It is, in principle, little more or less than this idea which was tried by the Wright Brothers in some of their early gliding experiments. Like most things of this kind, however, there is all the difference between the broad principle and the detail of carrying it into effect on a practical machine. It is the detail that makes the Dunne monoplane such an original design.

Among the other machines illustrated herewith, the Piggott monoplane is a remarkable example of the ultra-stream-line body, for in it the engine, pilot and passenger are completely inclosed. The Nieuport monoplane is an example of the surfaced frame, which may be described as the practical stream-line body of the moment, and the Blackburn monoplane, which is an interesting British-built machine, is another example in the same category.









* Reprinted from *Flight*.

The Grade of Iron Ores in Relation to the Question of Available Ore Reserves

IN his recent paper on "Geology and Economics," Prof. J. A. Kemp discusses the grade (richness) of the several domestic and foreign iron ores, in its relation to the question of the world's available ore reserves. We quote here the pertinent passages from the source mentioned:

"In early days and in remote situations only the richest iron ores could be mined. Magnetites for example in the lump from the Adirondacks afforded over 60 per cent metallic iron. Specular hematites from the Lake Superior districts necessarily yielded 65. For some years no one regarded them with respect if they contained less. Red hematites from Alabama af-

forded 45 to 50. The minor ores near the furnaces were often much lower—but they may be passed over for the moment in emphasizing the larger features. Magnetites in the Adirondacks are now concentrated before shipping, and in instances two and one-half to three tons are condensed to one of 65 per cent tenure. The crude ore carries 33-35 per cent. During the early years of the present decade the general average yield of Lake Superior shipments fell off about one per cent per year—so that now the soft ores, so called in contrast with the hard lump specular of earlier days, range somewhat above 50 per cent. Alabama ores, once 45 to 50, now are very uniform at 36 to 37. So far as the brown hematites are concerned, which in the form of lumps, crusts, pipes, etc., are distributed throughout ochres and clays, the percentage of available iron in the crude ore is lowest of all. We wash from eight to ten tons of crude in order to get one ton of concentrates of say 40-45 per cent in iron, and under favorable circumstances may treat much lower raw materials. Soft magnetites in Pennsylvania, which on the richer outcrops gave 45 to 50 per cent, are now dug in very large amounts with a yield of 43. If we take the total production of ore in the United States and the total production of pig iron, we find the yield in the large way to be about 50 per cent.

"In order to gain some idea of the comparative merits of these figures when set alongside the percentages in the ores produced in other lands, a few cases may be cited. Germany in 1907 produced 27,700,000 tons of ore, exported nearly 4,000,000 and imported 8,500,000. Of the local production three-quarters were obtained from Elsass, Lothringen and Luxemburg, whose percentage in iron ranges between 30 and 40, and is on the whole not very different from Alabama's present percentages of 36-37. Germany's imports, of course, range much above these figures, else the ore could not stand the freight charges from mines in such countries as Sweden, Spain and Algiers.

"Great Britain produced in 1907, approximately, 15,000,000 tons, of which about three-quarters were the so-called impure carbonates yielding 30-35 per cent iron. One-ninth of the total was red hematite at 50-55. The general average would be somewhat less than that of Alabama. Importations of richer ores, especially from Spain, helped to raise the furnace yield.

France in 1908 produced 10,087,000 tons, of which 88 per cent was mined in French Lorraine of the same type as the main German supplies. The ore ranged from 33 to 40 per cent—again not far from the Clinton ores of Alabama. We are justified, therefore, in saying that the largest part of the output of the next three producing countries of the world is about the same as the lowest grade of lump ore, which can be profitably mined under present conditions in the United States. When we estimate comparative reserves we must realize that in the Lake Superior region—our greatest producer—we pay no attention today to ores, which are, nevertheless, much richer than those of Great Britain and continental Europe."

A New Life Saving Buoy

The Miller Luminous Buoy

THE frightful loss of human life caused by collisions and other accidents at sea demonstrates the insufficiency of the apparatus provided for the prevention of death by drowning. The lack of proper means of illuminating, or even of indicating, the scene of accident increases the difficulty of giving aid at night. The recent sinking of the fishing steamer "Adolf" in the Baltic illustrates the consequences of the lack of proper life-saving appliances. Eleven of the crew escaped in a boat and were picked up by a Swedish steamer, but the remaining ten men, although they were provided with cork jackets and floated so near the Swedish vessel that their cries could be heard on board, were doomed to slow death by drowning because they could not be found in the darkness.

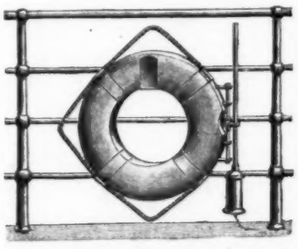


FIG. 1.—A NEW LIFE SAVING BUOY HANGING ON THE RAIL OF THE SHIP

How often the cry "Man overboard!" is heard, and how rarely the poor fellow is rescued. At night, especially, it is almost impossible for the ship to return exactly to the spot where the accident occurred. Life buoys thrown overboard in such cases are seldom picked up, although the ship has apparently not moved during the night. Even if the victim secures a buoy the boats sent to rescue him may cruise for hours in vain and finally leave him to perish, as it is impossible to determine his location, especially in a heavy sea.

Hence a means of indicating the position of a drowning person at night is required. The luminous buoys which are now in use, and which usually consist of a cork ring carrying a cartridge filled with a mixture that becomes luminous on contact with water, have many defects. It is difficult and even dangerous to store and handle the highly inflammable cartridges, which often fail at the critical moment. In a rough sea the flame cannot be seen by the drowning man to whom the buoy is thrown or by the crew of the rescuing boat. If the cartridge is attached directly to the buoy the latter may be burned or injured by corrosive gases, and if it is attached by a line of any considerable length, the victim may be unable to reach the buoy after finding the cartridge.

Capt. Miller, a retired German naval officer, has devised a greatly improved luminous buoy, the following description and illustrations of which we reproduce from *Die Umschau*. The essential features, which assure the efficiency of the device, are these: The flame is raised nearly three feet above the surface of the water, so that it is visible even in a heavy sea. The flame is 12 inches high and produces a light of 700 to 800 candle-power, which can be seen from a great distance and which burns three hours. The burner is attached directly to the buoy.

The new life saving apparatus (Fig. 1) consists of a cork ring of 17 inches interior diameter, to which the burner is attached by a cardan suspension, so that it maintains a vertical position despite the varying inclination of the ring, tossed by the waves. The lower end of the burner carries a water-tight and air-tight cartridge filled with calcium phosphide. When the buoy is thrown this cartridge is slightly torn with the fingers, or automatically by a short-chain attached to the cartridge and the ship's rail (Fig. 1). A few seconds after the buoy has struck the water, the hydrogen phosphide, which is generated by the action of the entering water on the calcium phosphide in the carton, bursts spontaneously into flame at the top of the burner. (Fig. 2.)

FIG. 2.—THE BUOY AFLOAT AND LIGHTED

The flame produces dense smoke as well as an intense light, so that the new luminous buoy may be used to advantage in the daytime, when it is much more easily located than an ordinary buoy. The flame is so high above the water that the heat and smoke do not endanger the user of the buoy. The efficiency and convenience of the apparatus have been demonstrated by numerous practical experiments.

RULES GOVERNING THE COMPETITION FOR THE $15,000 FLYING MACHINE PRIZE OFFERED BY MR. EDWIN GOULD.

1. A prize of $15,000 has been offered by Mr. Edwin Gould for the most perfect and practicable heavier-than-air flying machine, designed and demonstrated in this country, and equipped with two or more complete power plants (separate motors and propellers), so connected that any power plant may be operated independently, or that they may be used together.

CONDITIONS OF ENTRY.

2. Competitors for the prize must file with the Contest Committee complete drawings and specifications of their machines, in which the arrangement of the engines and propellers is clearly shown, with the mechanism for throwing into or out of gear one or all of the engines and propellers. Such entry should be addressed to the Contest Committee of the GOULD-SCIENTIFIC AMERICAN Prize, 361 Broadway, New York city. Each contestant, in formally entering his machine, must specify its type (monoplane, biplane, helicopter, etc.), give its principal dimensions, the number and sizes of its motors and propellers, its horse-power, fuel-carrying capacity, and the nature of its steering and controlling devices.

3. Entries must be received at the office of the SCIENTIFIC AMERICAN on or before June 1st, 1911. Contests will take place July 4th, 1911, and following days. At least two machines must be entered in the contest or the prize will not be awarded.

CONTEST COMMITTEE.

4. The committee will consist of a representative of the SCIENTIFIC AMERICAN, a representative of the Aero Club of America, and the representative of some technical institute. This committee shall pass upon the practicability and efficiency of all the machines entered in competition, and they shall also act as judges in determining which machine has made the best flights and complied with the tests upon which the winning of the prize is conditional. The decision of this committee shall be final.

CONDITIONS OF THE TEST.

5. Before making a flight each contestant or his agent must prove to the satisfaction of the Contest Committee that he is able to drive each engine and propeller independently of the other or others, and that he is able to couple up all engines and propellers and drive them in unison. No machine will be allowed to compete unless it can fulfill these requirements to the satisfaction of the Contest Committee. The prize shall not be awarded unless the competitor can demonstrate that he is able to drive his machine in a continuous flight, over a designated course; and for a period of at least one hour he must run with one of his power plants disconnected; also he must drive his engines during said flight alternately and together. Recording tachometers attached to the motors can probably be used to prove such performance.

In the judging of the performances of the various machines, the questions of stability, ease of control, and safety will also be taken into consideration by the judges. The machine best fulfilling these conditions shall be awarded the prize.

6. All heavier-than-air machines of any type whatever—aeroplanes, helicopters, ornithopters, etc.—shall be entitled to compete for the prize, but all machines carrying a balloon or gas-containing envelope for purposes of support are excluded from the competition.

7. The flights will be made under reasonable conditions of weather. The judges will, at their discretion, order the flights to begin at any time they may see fit, provided they consider the weather conditions sufficiently favorable.

8. No entry fee will be charged, but the contestant must pay for the transportation of his machine to and from the field of trial.

9. The place of holding the trial shall be determined by the Contest Committee, and the location of such place of trial shall be announced on or about June 1st, 1911.

Stone Composition for architectural ornaments.—Dissolve 8 parts of glue and 1 part of gum arabic in 12 parts of water and heat the solution to the boiling point. During boiling stir in 12 parts of paper pulp. Mix the whole with washed chalk. Press the paste into well-oiled molds, allow it to dry. When hard soak it with hot linseed oil.

Diesel Marine Engines*

A Resume of Recent Performances

By Herr Th. Saeuberlich of Osterholz-Scharmbeck

SINCE the days of the old low-pressure steam engines there has been no time when marine propulsion attracted more attention than to-day. In the place of the highly developed steam engine, the efficiency of which it appears impossible further to increase, the Diesel engine is now making its way for marine purposes. It is at the present moment the most perfect oil engine. According to recent experiments, the heat efficiency amounts to from 33 to 35 per cent, against 23 per cent with gas engines and 13 per cent with the best superheated steam engines. This arises from the direct burning of the fuel in the cylinder, by which means perfect combustion is attained.

In its manufacture the Diesel engine is known to demand great care in the choice of materials for most of its parts. But in view of the present-day knowledge with regard to metals, and the ease with which every sort of high-class and suitable material specially adapted for its purpose can be obtained, and above all, in consequence of the vast strides made in machine tool manufacture, there is no particular difficulty in turning out Diesel engines.

The large Diesel motor is very similar in its construction to the steam engine, and its development will, like that of the large gas engine, follow the example set in steam engine construction.

The prejudice against Diesel motors which still exists in shipbuilding circles has to a great extent broken down, and recently it has become clear that various shipyards are in the position to build Diesel engines, free from faults and reliable in working, even with their present equipment.

Hitherto the Diesel engine has been made almost exclusively single acting. As a rule the four-stroke cycle method has been used, but recently the two-stroke cycle has come into prominence. The efforts to utilize the Diesel engine for quite large undertakings, and finally for the propulsion of large vessels, have given an impulse to the employment of double-acting engines both on the four-stroke and two-stroke cycles. Indeed, such progress has already been made that ultimate complete success cannot be doubted, and leading shipowners, having recognized the great value of internal combustion engines, are already one by one approaching the shipbuilders with their orders.

The constructor is now confronted with the task of giving to the Diesel engine the reliability in working and capacity for maneuvering which distinguish the marine steam engine, and further, in consequence of the continual decrease in boiler plant, to find gear simple enough in handling and maintenance to suit the rough requirements of a ship's auxiliariese.

The advantages of the Diesel engine for marine purposes as compared with the steam engine differ according to the type of ship and the size of the equipment, but in general the following are among the most notable: The gain in useful space by the reduction of boiler plant and small size of the fuel

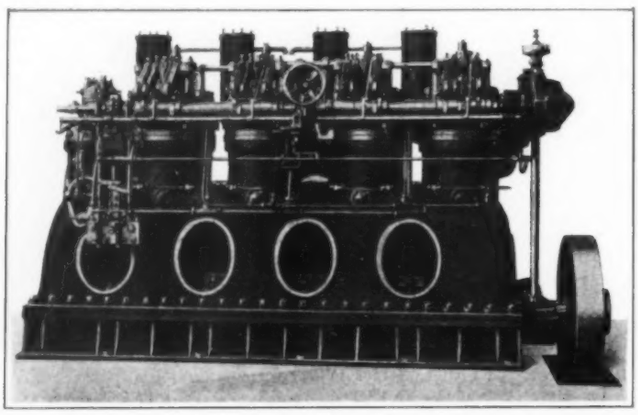
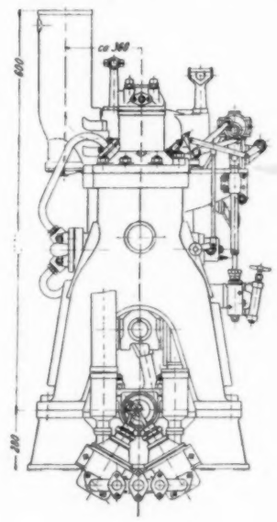
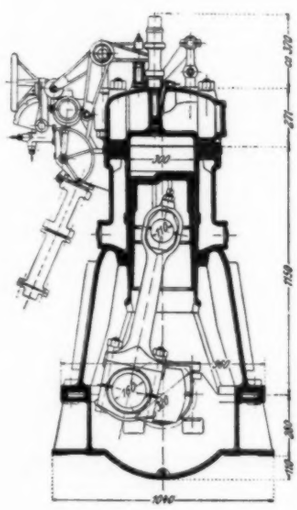


FIG. 1.—200 HORSE-POWER REVERSING DIESEL ENGINE OF THE "FRERICHS"





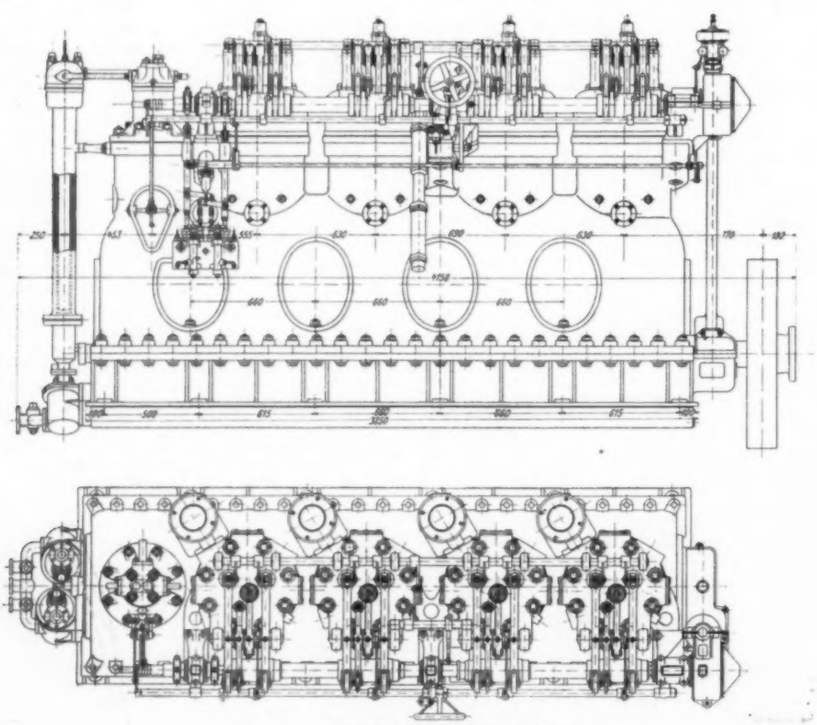


FIG. 2.—ENGINES OF THE "FRERICHS"

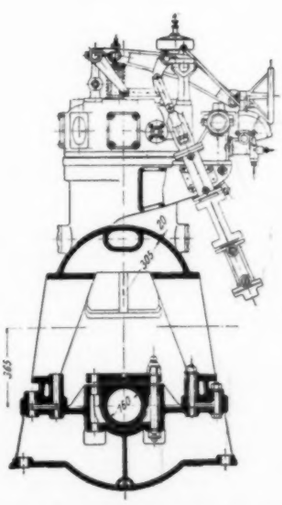


FIG. 3.—END ELEVATION AND SECTIONS

*Abstract translation by *The Engineer* (London) from a paper read before the Schiffbautechnischen Gesellschaft and published in the *Journal* of the Society by Julius Springer, Berlin.

holders; increased capacity due to the small weight of the engine plant and the fuel; utmost utilization of the otherwise limited useful space taken for fuel bunkers; gain in time, and economy of wages, due to quicker and easier bunkering, and also to decrease in coal trimming; quicker starting of the engine; reduced and easier management; personal and space economy by reduction of the number of the stokers; reduced cost of fuel; cooler engine rooms, resulting in the increased mechanical capacity of the personnel, especially in hot climates; the possibility of carrying more fuel, and therefore enlarged field of action.

But the introduction of Diesel marine engines also involves the solution of recent economic and constructional problems, of which the chief are the following: (1) The lack of suitable fuel in many harbors; (2) the lack of steam for actuating the auxiliary engines on deck and in the engine room, as well as for heating.

The engines here dealt with are the first marine Diesel engines built according to special design and put into service by a shipyard on the North Sea—J. Frerichs & Co., in Osterholz-Scharmbeck and Einswarden—and they form another link in the unceasing progressive development of the marine Diesel engine. They are (1) the direct reversing four-cylinder Diesel engine of a maximum effective 200 horse-power, with 360 revolutions per minute, fitted to the service boat "Frerichs," built by the above-named firm; (2) the 90 effective horse-power two-cylinder marine Diesel engine and reversing gear for driving the herring lugger "Ewersand," which is employed by the Brake Herring Fishing Company in Brake.

The Service Boat "Frerichs."—This service boat is a single-screw vessel built according to the rules of the German Lloyd for small coasting traders, and has been in use since the spring of 1910. She serves for the special purpose of communication between the shipyard in Einswarden and the opposite bank of the Weser, but especially for towing. For this purpose she is equipped with a strong towing gear. The towing power amounts to about 2,000 kilogrammes measured on the rope. The fuel employed is the so-called gas-oil, 1,000 kilogrammes of which are provided in two tanks under the cabin; double this quantity could, however, have been conveniently carried. These 1,000 kilogrammes permit of a voyage of 240 sea-miles at 9.5 knots, a distance which corresponds to about the voyage from Bremerhaven to Hamburg and back.

The vessel in external appearance is like a steam tug, since she has a funnel for carrying off the gases. With a length of 18 meters, she has a very spacious engine room. On deck, near the pilot house and other deck erections, is a large cabin affording room for twenty people. The existence of this roomy accommodation is due to the omission of boiler and coal-bunker space. The motor, Fig. 1, is a reversing four-cylinder four-cycle engine, direct coupled to the propeller shaft; at 360 revolutions it develops 200 effective horse-power, measured on the fly wheel, and gives the ship a maximum speed of about 10 knots. Its weight is about 10,000 kilogrammes.

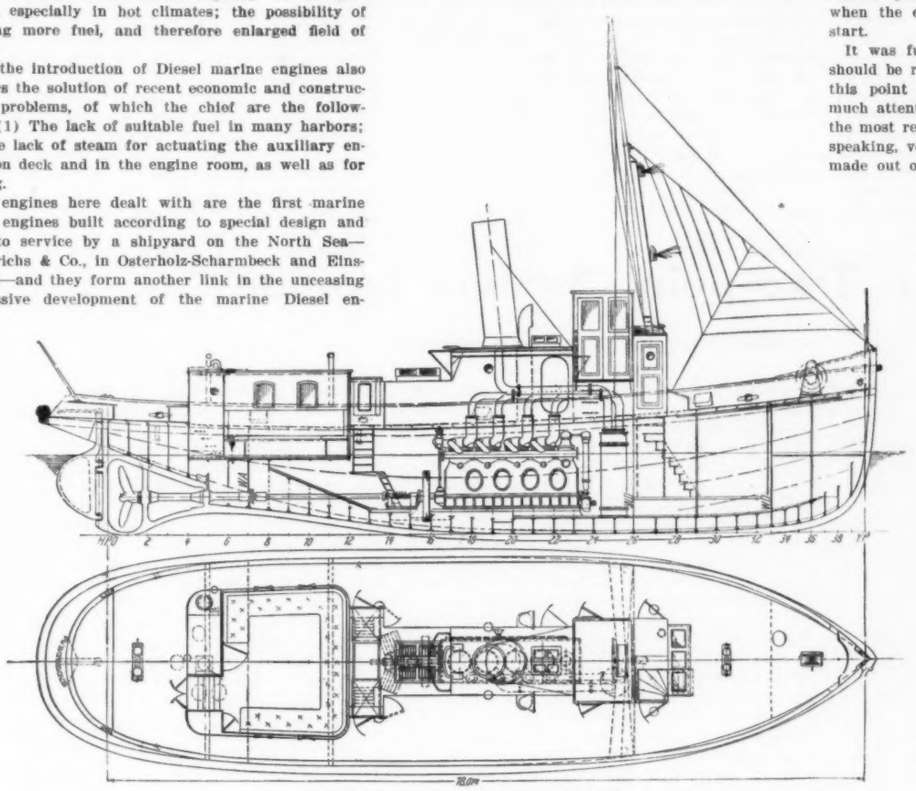


FIG. 4.—THE SERVICE BOAT "FRERICHS"

The reversing gear is actuated by compressed air, abundance of which is available, which moves the horizontal cam shaft endwise, thus bringing a second set of cams into action. Starting can be made quickly and safely, and can even be effected in one second. By a special arrangement of the compressor, perfect certainty is guaranteed with regard to the starting of the engine in either direction, even in the event of the motor stopping on the dead center. The valve gear of the motor is the simplest imaginable. All the necessary movements and arrangements are combined in a single mechanism. For the entire manipulation, including the regulation of the motor for high or slow speed, all that is required is a single lever, which for convenience is designed as a hand wheel.

The cooling water pumps and Lenz pumps are driven by the engine crank shaft by an overhung crank, and are—see Fig. 3—fixed to the common base plate.

The hot exhaust gases are cooled with water on their discharge from the cylinder in a double-walled chamber. After their union in a collecting pipe they are conducted into a large condenser which acts the part of a silencer. From there the exhaust pipe leads into the funnel, where the exhaust gases pass into the air.

The Lenz pump provides cooling water for the exhaust. The compressed air which is required for maneuvering is generated by the motor itself by means of a two-stage compressor which constitutes, as it were, the fifth cylinder of the motor. It is received in six large receivers—Fig. 4—which are placed along the side of the engine room and made fast to the ship's side, where they take up little room. Further, a smaller air receiver is also arranged on the port side. From it the air for the injection of the fuel into the cylinder and for reversing is taken. The six large receivers serve only for starting. The air used for starting is during the voyage gradually restored again from the small supply tank. In the construction of the motor the utmost simplicity was sought, and it was especially demanded that the number of the cylinders and the movable parts should be limited as far as possible.

To start a four-cycle motor in any position at least six cylinders are required if the usual method is adopted. It was, however, desired to limit the number to four cylinders, and a way was found by making use of the compressor direct coupled to the motor. This compressor is of special design and is provided with a gear which makes it possible to use it as a motive cylinder driven by the air from the receivers when the engine cylinders are not in a position to start.

It was further required that the cost of the plant should be reduced to the lowest possible amount. To this point of view the constructor cannot pay too much attention, since the cost of Diesel engines until the most recent times has always been, comparatively speaking, very high. The base plate of the motor is made out of cast iron and in one piece. It is closed underneath, and the separate crank pits are connected below by channels, so that the lubricating oil can flow to one end. The main bearings—Fig. 3—are recognizable as, on the whole, similar to the usual type in ship construction; the lower brass is rounded and therefore easy to remove; the upper, on the contrary, is squared. A plate of Siemens-Martin steel takes the place of the bearing cap.

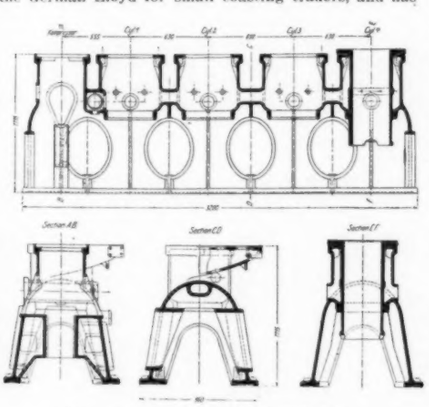


FIG. 5.—CAST IRON STANDARDS

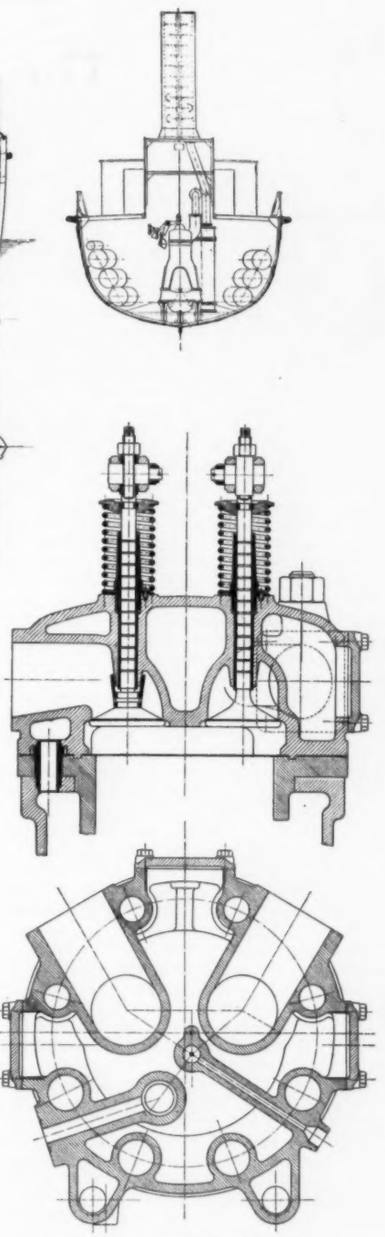


FIG. 6.—CYLINDER COVER

The general form of the standards will be gathered from Fig. 5. It will be seen that great care has been taken to avoid sharp corners and sudden changes of form. The whole piece is a single iron casting. The lower part is semi-cylindrical above, and the ends of

it are domed. The two walls are splayed outward to the base, and pierced by large elliptical openings. The cylinder liners fit the casting as shown, and the water jacket is kept tight by a calked leaden ring. All the jackets are in communication with each other by the passages shown in the drawing. Round cleaning holes are provided in each jacket. Between the compressor and the adjacent cylinder a square box is formed in the casting, which constitutes an intercooler for the compressor. The brackets, which support the valve shaft, are also cast on. The thickness of the casting is throughout about 20 millimeters.

The cylinder cover is the largest and heaviest casting in the engine, and on it are collected all the principal valves—the suction valve, the exhaust valve, the starting valve, and the fuel valve. All these parts have to be got into a constricted area little bigger than the piston diameter, and yet to avoid unequal thicknesses of metal reasonable spaces must be left between the separate parts. This arrangement is also necessary to insure equal cooling, and to avoid stresses being set up by unequal heating. Furthermore, an exceedingly sound casting is absolutely essential, particularly at the joints and valve faces, and at those surfaces subjected to the high internal pressure in the cylinder or connected with the high-pressure air supply.

To carry out all these requirements, however, presented little difficulty. As may be seen from the engraving, Fig. 6, the suction and exhaust bends are separated from the two tubes or passages which take the starting and fuel valves. The exhaust bend is entirely surrounded by water, and is of such a shape as to give an easy flow to the gases. The exhaust and admission valve seat direct on the cover, for in no other way was it possible to bring them so close together. It may be objected to this arrangement that dismantling is far more difficult than when separate valve cages are employed, as it involves the removal of the whole cylinder cover, but in an engine of this size no trouble in this direction has been experienced. The only real objection is that the part of the valve spindle exposed to the hot gases may wear more rapidly than the remainder which is water cooled, but to reduce this objection the lower part of the spindle is protected by a cone from the direct impact of the hot gases. In the case of larger valves the employment of a liner is, of course, recommended. In order to make the cooling as effective as possible, the walls are made only 12 millimeters thick.

From the foundryman's point of view the casting of the cover presents now no difficulty, but before the best mixture was found a considerable number were tried. In the tests the fact that only the closest and densest blends should be employed was disregarded, and it was proved that the best results were obtained with the iron in ordinary use for steam engine cylinders. All that is required is to use special care during casting and to keep the liquid iron after the mold is full in constant motion by means of a pump, to make sure that the mold is completely filled and the iron homogeneous.

(To be continued.)

The Two-point System Ignition

Merits of the Scheme Outlined

A TALK on ignition and ignition methods given by Roger B. Whitman of the Bosch Magneto Company not long since before the Long Island Automobile Club developed the merits claimed for the two-point system. Mr. Whitman dealt with the details of ignition and its method. His paper is given almost in its entirety below:

The state of perfection of the present day internal combustion engine has not been reached without deep study and investigation, in the course of which it has been realized that ignition has vastly more to do with efficiency than was at first believed.

The early conception of ignition was the production of a spark some time toward the end of the compression stroke, and if this spark was successful in igniting the mixture that was all that was desired. The character of the spark, the accuracy of its production, or the exactness of its timing were points that were disregarded by the designer, because he did not understand that these had any bearing on the power output or on the fuel consumption of the engine.

The modern designer takes an entirely different view of the subject, however, and it may be of interest to outline the problem as it is now understood.

To appreciate the fine points of ignition as they are understood to-day the engine must be considered in its true light as a heat engine pure and simple.

The mixture that is drawn into the cylinder during the inlet stroke represents a certain heat value, and the efficiency of the engine depends upon the manner in which this heat is applied to the expansion of the gases. Any condition by which some of this heat is lost or by which it is not applied directly to the forcing of the piston outward on the power stroke will reduce engine efficiency.

The first step in the securing of efficiency will be to study the points at which losses of heat may occur and to adopt means by which these losses may be prevented.

The charge of mixture represents a certain heat value and has a certain maximum pressure. To exert the greatest possible proportion of this pressure against the piston each particle of mixture should be made to give up its heat at the instant when the piston is at the end of the compression stroke and ready to move outward on the power stroke.

To gain this result it would be necessary to ignite each particle of the mixture at the same instant, and thus to have ignition and combustion occur at top dead center. The mixture would thus be compressed into a minimum space before ignition, and the rise in pressure due to combustion would then be most abrupt, the piston being driven outward with maximum force.

No existing ignition system will permit the ignition of all of the particles of mixture at the same instant. The system in use therefore permits ignition of the mixture at one or two points from which the flame is expected to communicate itself to the remaining mixture particles.

In a perfect mixture each particle of gasoline vapor will be surrounded by the particles of air necessary for combustion, and to ignite the mixture it will be necessary to raise the temperature of these particles to the point at which the chemical change known as combustion will occur.

Under usual motor conditions the heat developed by the electric spark is depended upon to raise the temperature of certain of these particles to the point at which they will ignite, and the flame thus started is communicated to the particles of the mixture immediately surrounding it, this being propagated throughout the entire charge.

To our senses the spread of the flame from the point of ignition is instantaneous, but in comparison with the speed at which a gasoline engines operates the time required is very considerable and must be taken into consideration. Thus there enters into our calculations the period of time that must elapse between the instant at which ignition occurs and the instant at which the entire charge will be inflamed.

We desire to apply to the piston the greatest pressure possible, and obviously the greatest possible pressure will be produced at the instant when combustion is complete. At this instant, therefore, the piston should be at the top of its stroke. We must not overlook the fact, however, that some pressure is produced at the instant when ignition occurs and that this pressure will be constantly increasing as combustion spreads. If combustion is to be complete when the piston is at its top point it is clear that ignition must occur while the piston is still moving upward on the compression stroke. For the last portion of its stroke the pison will therefore be subjected to this pressure, which is rising to maximum, and by which the piston will tend to be driven backward, at the same time the momentum of the flywheel is urging the piston upward. Some of the power of the engine will thus be required to force the piston upward, and in this is found one of the most serious of the losses in engine efficiency. If the engine is going at a sufficient speed the momentum of the flywheel will force the piston against the pressure in the combustion space to top center, but the result of the conflicting pressures will be shown in abnormal wear of the wrist pin, crank pin, and main bearings.

You have all had experience with a back fire when cranking an engine and know that it is the production of maximum pressure in the combustion space before the piston reaches the top of its stroke, the result being that the engine starts to run backward. This same condition in a lesser degree exist in a running engine under the normal condition of ignition occurring before top center.

The charge of mixture represents a certain heat value and can be made to exert a certain definite pressure upon the piston. To get the best possible results all of this pressure should be exerted against the piston when the latter is at the top of its stroke. If some of the pressure is exerted before the top center is reached less pressure will, of course, remain to act on the piston during the power stroke. This entails a double loss, for not only is the rotation of the crank shaft somewhat retarded, but the maximum pressure developed at top center is reduced. The effect is shown in an increase in the consumption of fuel and in a reduction of the power output.

Another loss that results from ignition earlier in the stroke is due to the absorption of heat by the cylinder walls; the surfaces being of metal are natural conductors of heat, and of course the longer the period during which the flame is in contact with these surfaces the greater will be the heat absorbed and wasted in this manner.

The obvious way to reduce loss of power from these causes is to produce ignition as late in the stroke as possible, but in this we are limited by the necessity for having combustion complete at top center.

The remedy will therefore be to hasten ignition as much as possible, or in other words to reduce the time necessary for the propagation of the flame throughout the mixture.

One of the most important factors in this is the location of the spark plug, which should be so placed that the distances through which the flame must be spread are as short as possible. If, for instance, the plug is located in the inlet valve cap the distance through which the flame must spread will be practically maximum, and the operation will require more time than would be necessary if the spark plug were located in the cylinder head. Furthermore, the plug should be located that its points are actually plunged in the mixture and not set in a cavity or pocket. Engines are occasionally seen with valve caps that are solid and possibly an inch thick. If a standard plug is screwed into such a cap the spark points will be found some distance up the hole, the spark will ignite the mixture which is in the hole and some little time will be required for the flame to spread down to the hole and to be communicated to the mixture.

Such a construction will require considerably more advance of the spark than would be necessary if the spark points were in direct contact with the charge.

The size of the ignition spark is also a factor that determines the time required for combustion. The ideal ignition spark should be a mass of flame with as large a surface as possible, for this will result in the ignition of a large number of mixture particles. It should be understood that the spark must come into actual contact with the mixture particles in order to ignite them, and if the spark is thin it will be quite possible for it to pass through a throttled mixture without actually coming into contact with any of the particles. With a spark that is in the nature of a flame this cannot take place. A large spark not only insures ignition, but makes combustion more rapid, for combustion will certainly be more rapid if, for instance, a hundred mixture particles are ignited by the spark instead of but one.

Following along this line brings us to the proposition that it might be better to ignite the mixture at two widely separated points instead of at but one, on the theory that this will reduce the time necessary for the propagation of the flame.

If a spark plug is placed in the inlet and a second one in the exhaust valve, and sparks are caused to occur at these plugs at the same instant, the time required for the spread of the flame throughout the whole charge will be much less than would be necessary were the flame to originate at one side and be required to spread across the entire width of the combustion space.

This has been theoretically admitted for a long time, but the difficulty in its practical application lay in the securing of apparatus that would permit the production of two sparks at absolutely the same instant.

Ignition apparatus of this character has now been perfected, however, with results that are satisfactory from every point of view. It may be said at the beginning that it is essential to locate the spark plugs properly. If the two are set side by side in the inlet valve cap, for instance, there will be no gain through the use of two spark ignition over one spark. To secure proper results from this system it is necessary to separate the plugs and to locate them so that the flame will have an approximately equal distance to spread in all directions from each.

A series of comparative tests was recently made on

an engine arranged for operation either with one spark or with two. The engine was a four-cylinder 3 9/16-inch bore by 4¾-inch stroke, and was connected to an electric dynamometer that made it possible to gage the power output very accurately.

With single spark ignition the maximum output of 24 horse-power was reached with an ignition advance of 45 degrees; with two-spark ignition the same output of 24 horse-power was obtained with an advance of but 18 degrees, and a maximum output of 28 horse-power was obtained with an advance of but 32 degrees. In other words, the maximum power output possible with single spark ignition was equaled by two-spark ignition at considerably less than one-half the advance, while with two-spark ignition it was possible to increase the maximum power output by 16 per cent.

At first sight it seems somewhat extraordinary to claim that the power output of an engine will be increased 16 or more per cent by producing ignition at two points in the cylinder instead of at but one, but the line of reasoning that we have followed makes it clear that the gain is due to the preventing of losses that follow early ignition.

The two-spark ignition system has been used on racing cars since last fall, the Vanderbilt race marking its first appearance on American roads. In that race Dawson's Marmon car was equipped with a Bosch magneto of the two-spark ignition type, and no one who saw it run could fail to be impressed with its extreme speed and its extraordinary ability to pick up after a slowdown.

All cars entered in races subsequent to the Vanderbilt have been equipped with two-spark ignition, and to get down to actual results it may be said that the Marmon and Lozier cars showed an actual increase in speed of from four to five miles an hour on changing from single to two-spark igition. (Bosch.)

This system unquestionably marks the greatest improvement that has been made in engine operation for a number of years past. The magneto itself is of great simplicity, for it is identical with the ordinary magneto except that a second distributer is provided. In the magneto of the independent type one end of the armature winding is grounded on the armature core, and the current after passing through the spark plugs returns to the grounded end through the metal of the engine and magneto. In the two-spark magneto this end of the winding instead of being grounded on the armature core is carried out through the distributer and grounded on the engine through the second spark plug. The circuit therefore consists of the armature winding, one distributer, one spark plug, to engine ground, to the metal of the engine, and thence to the armature winding by the second spark plug and second distributer.

Not the least advantage of this system is its great reliability, for one plug may become fouled without interfering in the slightest with the operation of the other. It has further been many times demonstrated that oil has far less effect on this system than it has on a single-plug system, and that overoiling that would put a single spark magneto completely out of business will not interfere in the slightest with the perfection of the operation of two-spark ignition.

We have seen the necessity for causing ignition to occur as late as possible in the stroke, and it follows that we must use ignition apparatus that will produce the spark at exactly this point and at no other.

If the apparatus selected does not produce this result, and if it permits the spark to occur a little earlier on one stroke and a little later on another the result will be an unsteadiness in the operation of the engine, a reduction in power output and an increase in gasoline consumption.

Any one who has had experience with an automobile knows that the engine will run more steadily and more powerfully on a high tension magneto than it will on a battery and coil system, but the reason for this is not always understood. It lies largely in the fact that the magneto produces a spark absolutely accurately and without variation, while with the coil and battery system the point at which the spark will occur will vary considerably.

The battery timer will make contact definitely and at the proper instant, but this does not mean that the spark is produced accordingly.

Upon the closing of the battery circuit by the timer the battery current is permitted to flow through the primary winding of the coil, with the result that the core becomes magnetized. The effect of this is to draw the vibrator blade away from its contact and thus to break the battery circuit, the consequent collapse of the magnetic field causing the induction of a high tension current in the secondary winding. It is this current that furnishes the spark.

It is seen that the electric current is required to do certain work between the closing of the circuit by the timer and the production of the spark at the plug and the lack of accuracy in the system lies in the fact that the current does not always consume the same time in performing those functions.

This can be demonstrated on apparatus that consists of a shaft that may be driven at variable speed by an electric motor. This shaft carries a pointer that travels around the inner side of a graduated ring. One end of the shaft carries a battery timer, while the other end drives a high tension magneto, the magneto armature and the timer revolving at the same speed.

The circuit is so arranged that the spark produced by the magneto or by the coil may be caused to pass between the moving pointer and the graduated ring.

Turning the apparatus slowly by hand with the magneto thrown into the circuit will show that the spark is produced at the zero point of the graduation. By throwing in the electric motor the speed may be increased to anything up to about 1,500 revolutions a minute, and it will be seen that the magneto spark invariably occurs at the same point.

In other words the point in the rotation of the shaft at which the magneto spark occurs is not affected by the speed.

As the speed increases the igniting ability of the spark evidently increases, for its size can be seen to increase, until at 1,500 revolution a minute it endures for about 30 degrees of rotation.

Throwing the magneto out of circuit and cutting in the battery, we will again turn the apparatus slowly by hand. The first battery spark will be seen to appear at the zero point, and at low speed there is an apparent sheet of flame for the entire 40 degrees during which the timer is making contact.

Running the speed up slightly, we will see that this sheet of flame is broken up into a series of single sparks, which occur very closely together. Throwing in the electric motor, we will see that at 500 revolutions a minute the distance between the successive sparks is increased very considerably.

Each of these sparks corresponds to a single movement of the vibrator, during which the battery circuit through the primary winding of the coil is broken.

We will see another interesting thing, which is that the first spark no longer occurs at the zero point, but some degrees after it. On increasing the speed to 1,000 and then to 1,500 revolutions we will finally find that during the 40 degrees, when the timer is making contact, only two sparks are produced, which means, of course, that during that period of time the vibrator has had time to move but twice.

The vibrator will make a certain number of vibrations a second, say 300. If the timer holds its circuit closed for one second there will, of course, be 300 sparks produced at the pointer. If, on the other hand, the timer holds the circuit closed for but 1/100 of a second there will be time for but three movements of the vibrator, and in consequence only three sparks will be produced. Furthermore, the first spark, instead of occurring at the zero point, now appears some 20 or 25 degrees afterward, and we immediately recognize this lag as representing the time required for the electric current to perform its various functions between the instant when the timer closes the circuit and the instant when the spark appears.

The delay in the production of the spark may be corrected by moving the timer so that contact is made some little time before the spark is actually required. The lag due to the work that the electric current must perform is thus overcome mechanically by moving the timer.

The moving of the timer, however, does not correct the shifting in the position of the spark, and this cannot be corrected by any means that could be used on an automobile.

If the spark is observed it will be seen that it does not always occur at the same point, but varies considerably, the total variation being 8 or 10 degrees.

At the instant when the timer closes the circuit the vibrator contact may also be closed; but on the other hand, the vibrator contact may be open, the blade not having come to rest from the movement caused by the previous closing of the circuit. A slight variation in the voltage of the battery will also cause a difference, for the lower the voltage the less able will the primary current be to force itself through the winding of the coil.

The coil offers resistance, of course, and it takes certain electrical pressure to overcome it. To overcome it more rapidly the pressure must be increased, or in other words the voltage in the battery must be raised.

If we could change the voltage of the battery to correspond with every change in the speed of the engine we might get better results, but we would still need a vibrator blade that we could be sure would be in actual and good contact every time the timer closes the circuit. Furthermore, we would find it necessary to assure ourselves that the circuit was actually closed at the timer, for when the timer contacts are covered with grease or dirt the circuit will not be actually closed until the moving part of the timer is half way across the timer contacts.

The timer that is used with the testing apparatus is operating under perfect conditions and the contacts are clean and uncorroded. This is not often the case with the timers that are used on automobiles, and consequently the results of the use of such apparatus on an automobile are far worse than are here indicated.

Some Unsolved Problems in Electro-Plating*

By GEORGE B. HOGABOOM.

As is well known, electroplating was the beginning of the science of electrochemistry, but it has lingered by the wayside and been neglected as a science, and to-day the unsolved problems are many.

Electroplating has been looked upon more as a trade than a science, and it is only during recent years that much study has been given to it by scientists, and that attention has been directed more to the electrolytic refining of metals than to the deposition of metal for decorative purposes. The solutions published by Roseleur in 1854 have been improved upon but little, and those who have published treatises upon the subject often give only a repetition of his formulæ. Nickelplating, as invented by Dr. I. Adams, is probably the only exception.

The field is broad, but its development has been left to the practical man, guided only by rule of the thumb. An electrochemist in the plating room of a factory is so rare that it probably can be said without fear of contradiction that they can be counted on the fingers of one's hands. The need to-day is mutual assistance in solving these problems and developing of new ideas. To a great extent they are useless each without the others—the plater producing results which he cannot duplicate—the electrochemist creating solutions that are not a commercial success.

So many phenomena have been encountered that to include the perplexing problems would necessitate a history of nearly every known solution and finish. The varying of the temperature and the electric current often proves a stumbling block, and these conditions cannot always be controlled. There is a vast difference between producing a homogeneous deposit at a minimum cost from a solution where the amount of cathode surface is being changed every twenty minutes, and a solution in which the amount of cathode surface is always the same and the rapid deposit of the metal is more desired than a deposit that can be easily burnished. Such would be the difference, for instance, between the surface of a sheet of electrolytic copper and that of a cast lead and antimony electrolier with its deep reliefs and where a coarse crystalline structure would destroy its beauty. In the discussion of electroplating problems, it must be borne in mind that a mere deposit of a metal is not all, but that the deposit must be soft and smooth and lend itself to a decorative process; the anodes should be capable of being reduced easily; the electrolyte must offer little resistance to the electric current, and, last, but not least, to the plater, who hears it so often that it becomes a part of him, the cost must be nominal.

DIFFICULTIES WITH SEVERAL METALS.

The automobile industry has brought about, more than anything else, the need of a heavy deposit of brass. At present this is done in a solution of cyanide of copper. The deposit is not only slow, but unsatisfactory, because of what is known as spotting out—a discoloration in spots which appears on the work after it has been polished and lacquered. Deposits on cast metal give the most trouble. It is probably caused by the acids or alkaline solutions being absorbed in the pores of the metal, or in the small blow-holes, and the deposit covering these holes partially, leaving minute holes through which the solution oozes out.

Several promising remedies have been suggested and tried, such as boiling out in some neutralizing chemical solution or placing in a drying oven for several days, but a satisfactory remedy has not been found. An acid brass solution would be a great advantage. There is an acid copper and an acid zinc solution, but no acid brass electrolyte. The difference between the deposit from a cyanide and a sulphat of copper solution well illustrates the advantage of having an acid brass solution.

The formula for a tin solution published by Roseleur is the most generally used to-day, as little, if any, improvements has been made upon it, although a good solution, which would give a heavy deposit,

* A paper presented before the American Electrochemical Society, New York.

is much desired. In Roseleau's solution the electrolyte is not replenished by the anode, but by the constant addition of a concentrated solution. This should be overcome, and would be appreciated by manufacturers of tin ware. While several solutions have appeared from time to time for plating upon aluminium, none of them is in general use, and a good electrolyte that would deposit gold, silver, brass or copper, so that it would stand burnishing and not peel off in time, could be used. The successful removal of a deposit of nickel from another metal without affecting the latter has not been accomplished.

UNSOLVED PROBLEMS.

To give all the unsolved problems in detail would make a lengthy paper, and a simple statement of those most desired will be given: An electrolyte that will remove the fire-scale from brass; also one that will produce a bright or a matte surface in place of using the present acid dips; an electric cleaner that will saponify the grease and take it into solution instead of driving it to the top, where it has to be constantly removed to prevent it adhering again to the work as the later is removed from the solution; a heavy deposit of lead on the inside of iron pipes, to prevent rapid corrosion; a method to coat electrogalvanized iron or steel with decorative metals without destroying the rust-resisting properties of the zinc; an alkaline nickel-silver solution that can be worked with a low voltage; a method of etching steel without destroying a resistance film of gelatine; some alkaline substance that would replace cyanide of potassium. This would be universally welcomed.

For the above suggestions, the writer is indebted to 100 different platers, who were kind enough to answer a request for unsolved problems. It may be interesting to note that 80 per cent of them requested an acid brass solution.

Something About Writing Inks

Notes on Fluidity, Durability, Corrosion and Copying

A GERMAN firm has had the good sense to enlighten the public in general, as well as its own customers in particular, concerning the properties of writing inks, and how to deal with these necessary fluids, as follows:

Fluidity.—Every writing ink loses water by evaporation, and also becomes less fluid by the addition of dust. For this reason only such ink stands should be used as have small openings, and these should be closed after use. When the ink gets thick it should be replaced by fresh; that which is spoiled by sediment should be thrown away—it costs only a very small fraction of a cent. Ink bottles should be kept closed and in a cool place; best inclosed in the ordinary pasteboard package.

Durability.—If steel pens, pieces of cork, or other foreign bodies get into the ink stand, they will spoil the best of ink. For this reason the stand should be cleaned every time before being filled; fresh ink should never be added to old, and different kinds of ink should not be mixed. Among other signs of spoiling may be mentioned change in color. If ink which is kept in a closed bottle and a cool place is spoiled, it is either originally bad, or is very old, and should not have been sold by the retail dealer.

Corroding of Steel Pens.—The points of the best steel pens would not last more than a week, even if that, when used with pure water, by reason of the friction on the paper. In addition to this, about 80 per cent of writer hold their pen obliquely, so that one point is more used than the other, and for this reason the pen is sooner out of service than it otherwise would be. One should not blame the ink when the pen is used up. Those who write all day should change the pen about every three days. The expense is but slight in comparison with the convenience; hardly a hundred pens a year—only about 50 cents. For each kind of ink a special pen should be used.

Dirty Pens.—The oftener one breaks off his work and lays by his pen without wiping it, the sooner it will be covered with deposit. If the ink is properly composed, this deposit will, however, be but slight, and cause but little inconvenience. The amount of deposit will be influenced more or less by the degree of smoothness of the pen itself.

Copies.—In choosing a copying ink, one should consider the following questions:

(a) The number of copies required. (b) The amount of time available for making the copies. (c) The manner of copying—whether with a platen press or a roller machine. (d) The kind of writing and copying papers.

And even after paying attention to all these points in the choice of the ink, one may get bad copies. For this reason the following hints should be observed:

(1) Copying with the platen press. For this process, both log-wood and nut-gall inks are suitable. The first have a great copying power and last very long; the second last very long in the bottle, but will not copy when the writing is old.

Rough writing papers—not excepting the finest—give poorer copies than smooth ones that are well sized. Cheap papers contain wood, and most post cards absorb the ink and make copying impossible. The thinner the copying paper, the plainer and the more legible will the copies be. Thick lines copy better than thin ones. Old writing must be pressed harder and longer than new. Where copying must be done in a hurry (that is, in large establishments with a very heavy mail), a copying ink is necessary which gives good copies, even with rush work. The best copying paper is the so-called pure silk paper; for several copies the yellow so-called export paper, or Japanese silk paper, is preferable. The copying paper should be made as wet as possible and superfluous water removed with blotting paper.

To obtain several (four to six) copies, as many sheets of copying paper should be moistened, without any paper between them, as are desired; the extra water is removed by blotting paper; and if the writing to be copied is fresh it should be pressed for a minute; if old, for five minutes. At first the pressure should be but slight, in order to give the ink time to free itself and enter the different sheets of copying paper. Heavy pressure at first gives wide lines and blots on the copy.

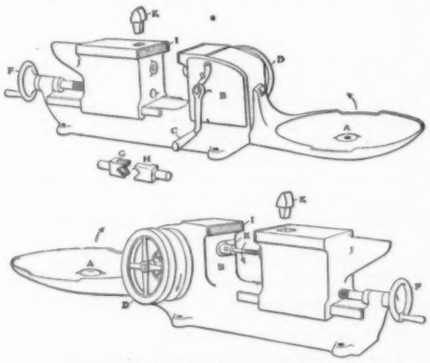
(2) In copying with the roller machines, it is better to use log-wood or aniline inks, because they are more readily printed off from the original, during the rapid passage through the rollers. Those who prefer the blue color of the iron and nut-gall inks can on a pinch use such for the copying machine, but only when the copying is done at once after writing, and the very thinnest copying paper is used. Specially thin copying paper is also necessary where several copies are to be made from the same original, one after another. For the first copy, the rolls may be turned more rapidly than for the others; the pressure at first can also be lighter.

It is very important to adjust the machine properly for the ink used. If several kinds of writing paper—rough and smooth—or different kinds of copying ink are used in the same office, it is just as necessary to adjust the machine for each, as in the case of the platen press.

In general, the same principles apply to the choice of paper and the processes with the roller machine as for copying in a platen press.

A "Universal" Tool

A NOVEL combination tool, designed especially for a private garage, has made its appearance. Both sides of this tool are shown in the line-cut herewith. At



A "UNIVERSAL" TOOL FOR GARAGES

A is located a forge that is given its blast through a tube leading to the central hole by a small fan inside the tool at *B* that is operated by the crank *C*. On the opposite side is located an emery wheel *D*, that is also operated by the crank *C*. This same crank *C*, through bevel gears, also drives a chuck *E* that will hold drills or similar tools for machining work, while the hand-wheel *F* can be used to feed the work up to the tool. The chuck can be taken out and the pipe grips *G* and *H* inserted in this hole and another one opposite and the tool used for a pipe vise, while an ordinary machinist's vise is located at *I*. The top and rear end of one vise jaw is formed into a blacksmith's anvil *J*, while an anvil chisel *K* is supplied, to fit the square hole for cutting off work.—*American Machinist.*

Lacto—A Scientific Summer Drink

THE popularity of summer drinks and ices is such as to make interesting any new addition in the nature of a frozen product. Many attempts have been made to present a drink from soured milk, flavored with fruit juices with more or less success, but in a recent bulletin, the Agricultural Department tells of a new frozen product which is called lacto, and has been developed toward perfection by the dairy section of the Iowa Experiment Station. First buttermilk was used as the basis without entire success, and later skimmed milk which had been soured by a commercial lactic acid culture was substituted for the buttermilk and combined with eggs, and various fruit flavors, giving a product which possessed a delicate flavor. It was found that lacto, which may be briefly described as a frozen product made of loppered, whole or skim milk with the addition of eggs, sugar, lemons and flavoring material, has a more pleasing flavor than sherbets and ices and contains considerable more nutriment, including as much protein as ice-cream, less fat and more acid. Out of 179 who sampled lacto, 128 pronounced it very good, 37 good, 6 fair, and 8 poor, and as compared with common vanilla ice-cream, 111 preferred lacto, 9 considered it equal to ice-cream and 59 preferred ice-cream. Comparing lacto to sherbet, 123 preferred lacto, 30 preferred sherbet, and 26 considered lacto equal to sherbet.

Artificial Fur

A NEW French process of making artificial fur, which has been patented by its inventor, M. Marche, merits description on account of its originality and ingenuity, if not because of its practical importance. Small pelts are sewn together, stretched, with the fur side up, on the flat bottom of a large pan, and covered with water, which is then frozen. The cake of ice is removed from the pan, and a slice, of the exact thickness of the skin, is sawed off the bottom of the cake. By melting this thin slice of ice the skins, destitute of hair, are recovered for use in the leather industry. The upper part of the cake of ice, containing the hairs, is placed with its base near a hot surface until a thin uniform layer of ice is melted and the lower ends of the hairs are exposed. The base of the cake is then varnished with a solution of India rubber, and after the varnish has become hard the ice is melted. In this way is produced a large, seamless artificial pelt, composed of the natural hair of a number of small pelts or pieces, attached to a sheet of india rubber. These artificial furs are cheap, as the natural skins are saved for other uses, and they are moth-proof, owing to the substitution of india rubber for animal tissues.

Cement for Repairing Stone Slabs, etc.—(a) Finely ground granite or standstone, or burned magnesite, in the absence of the latter, ordinary magnesite, is stirred with water glass into a paste and quickly worked. For all cements it is best to use potash water glass. (b) Granite, heavy spar, precipitated or ground fine as dust and hydrate of lime, in equal parts, are powdered into a paste with varnish. Hydrate of lime, with approximately 24 to 25 per cent of water is obtained by using equal parts by weight of hot water for slaking lime, allowing it to stand for 24 hours and then straining it off.

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